

**DFP-420**

**APPENDIX D**

**HUMAN ENGINEERING DESIGN GUIDELINES  
FOR  
VEHICLE-MOUNTED SETS, KITS, AND OUTFITS**

## DFP-420

### D1. SCOPE

D1.1. Scope. This appendix establishes specific human engineering design guidelines for the SATS. The requirements in this appendix represent a tailored version of MIL-STD-1472, which is the Army's general design standard for Human Engineering.

D1.2. Purpose. The purpose of this appendix is to present human engineering design criteria, principles, and practices to achieve mission success through integration of the human into the SATS and achieve effectiveness, simplicity, efficiency, reliability, and safety of operation and maintenance.

D1.3. Application. This appendix may be applied to the design of the SATS. It is not intended for application to off-the-shelf items selected for incorporation into the SATS, except as specifically noted herein. Nothing in this appendix should be construed as limiting the selection of hardware, materials, or processes to the specific items described herein.

D1.4. General. This appendix does not alter requirements for participation of human engineering specialists in development of the SATS to interpret and implement these practices and to provide solutions to human engineering problems which arise and which are not specifically covered herein.

D1.5. Manufacturing tolerances. When manufacturing tolerances are not perceptible to the user, this appendix should not be construed as preventing the use of components whose dimensions are within a normal manufacturing upper or lower limit tolerance of the dimensions specified herein.

### D2. APPLICABLE DOCUMENTS

The documents cited in this section are for reference only, and do not constitute a part of this standard. They are provided as a source of additional information.

#### HANDBOOKS

#### DEPARTMENT OF DEFENSE

DOD-HDBK-743	-	Anthropometry of US Military Personnel
MIL-HDBK-759	-	Human Factors Engineering Design for Army Materiel
MIL-HDBK-1908	-	Definitions of Human Factors Terms

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Standardization Documents Order desk, 700 Robbins Avenue, Bldg 4D, Philadelphia, PA 19111-5094.)

### D3. DEFINITIONS

Unless otherwise specified, terms are defined in accordance with MIL-HDBK-1908.

### D4. GENERAL REQUIREMENTS

## DFP-420

D4.1. Objectives. The SATS should provide work a environment which fosters effective procedures, work patterns, and personnel safety and health, and minimizes factors which degrade human performance or increase error. Design should also minimize personnel and training requirements within the limits of time, cost, and performance trade-offs.

D4.2. Standardization. Criterion for selecting off-the-shelf commercial equipment should include the degree to which the equipment conforms to this standard. Where off-the-shelf equipment requires modification in order to interface with other equipment, the modification should be designed to comply with the criteria herein. Redesign or modification of off-the-shelf commercial equipment for the sole purpose of complying with the requirements of this Appendix must have the approval of the procuring activity.

D4.3. Function allocation. Design should reflect allocation of functions to personnel, equipment, and personnel-equipment combinations to achieve: a. required time and safety, b. minimum number and level of skills of personnel required to operate and maintain the SATS, and c. required performance in a cost-effective manner.

D4.4. Human engineering design. Design should reflect human engineering and biomedical factors that affect human performance, including, when applicable: a. protection from thermal, toxicological, mechanical, electrical, electromagnetic, visual, and other hazards; b. adequate space for personnel, their equipment, and free volume for the movements and activities they are required to perform during operation and maintenance tasks under both normal and emergency conditions; c. adequate physical, visual, auditory, and other communication links between personnel and their equipment under both normal and emergency conditions; d. efficient arrangement of operation and maintenance workplaces, equipment, controls, and displays; e. design features to assure rapidity, safety, ease and economy of operation and maintenance; f. compatibility of the design, location and layout of controls, workspaces, maintenance accesses, stowage provisions, allocated tasks, and control movements with the clothing and personal equipment to be worn by personnel operating and maintaining the SATS.

D4.4.1. Safety. Design should reflect applicable system and personnel safety factors, including minimizing potential human error in the operation and maintenance of the SATS.

D4.4.2. Layout. Units should be laid out so that a minimum of place-to-place movements will be required during operation.

D4.4.3. NBC survivability. The SATS should permit performance of mission-essential operations, maintenance, and decontamination tasks by suitably clothed, trained, and acclimatized personnel for the NBC environments required by the system.

D4.4.4. Simplicity of design. The equipment should represent the simplest design consistent with functional requirements and expected service conditions. It should be capable of being operated, maintained, and repaired in its operational environment by personnel with a minimum of training.

## D5. DETAILED REQUIREMENTS

## DFP-420

### D5.1. Anthropometry.

D5.1.1. General. Design and sizing should ensure operability and maintainability by the user population. Generally, design limits should be based upon a range from the 5<sup>th</sup> percentile female to the 95<sup>th</sup> percentile male values for critical body dimensions, as appropriate. This design range from the 5<sup>th</sup> to 95<sup>th</sup> percentile values will theoretically provide coverage for 90 percent of the user population for that dimension. **NOTE:** The data provided herein are intended for use as individual (stand-alone) parameters, which should be adequate to support design of the SATS. However, the relationships or correlations between body measurements are highly variable. If two or more dimensions are used simultaneously as design parameters, they cannot be assumed to be additive; appropriate multivariate data and techniques must be utilized. Simultaneous use of two or more anthropometric dimensions as a design parameter should require approval of the procuring activity.

D5.1.2. Anthropometric data. Anthropometric data for the design and sizing of workspaces involving the standing position are presented in Table 1 and illustrated in Figure 1. Fifth and 95<sup>th</sup> percentile values are given for various body dimensions. Suitable allowances should be made for heavy clothing or protective equipment when required. Clearance dimensions should be not less than the 95<sup>th</sup> percentile values for men; limiting dimensions should be not more than the 5<sup>th</sup> percentile values for women, shown in Table I. The intended user population for the SATS consists of Military Occupational Specialty (MOS) for maintenance. Maintenance Workers are required to possess greater physical strength than the general population, and the criteria herein have been adjusted accordingly.

D5.1.3. Use of Data. Use of these data should consider (a) the nature, frequency, safety, and difficulty of the related tasks to be performed by the operator of the equipment; (b) the position of the body during performance of these tasks; (c) mobility or flexibility requirements imposed by these tasks; and (d) increments in the design-critical dimensions imposed by the need to compensate for obstacles and projections.

D5.1.4. Adjustments. Because the above-cited anthropometric data represent light clothing measurements, suitable allowances in design-critical dimensions should be made for heavy clothing, protective equipment, and other worn or carried items when utilizing these data for design criteria.

D5.1.5. Clearance dimensions. Clearance dimensions (e.g., for accesses), which must accommodate or allow passage of the body or parts of the body, should accommodate the 95<sup>th</sup> percentile values for applicable body dimensions.

D5.1.6. Limiting dimensions. Limiting dimensions (e.g., reaching distance, control movement, displays, test points) which restrict or are limited by extensions of the body should accommodate the 5<sup>th</sup> percentile values for applicable body dimensions.

D5.1.7. Control and Display placement. All controls and visual displays mounted on vertical panels and used in normal equipment operation should be mounted 86 - 178 cm (34 - 70 in) above the standing surface.

**DFP-420****TABLE I.****Anthropometric data for clothed personnel, standing position**

	Percentile Values in Centimeters (Inch equivalents in Parentheses)*			
	5 <sup>th</sup> Percentile		95 <sup>th</sup> Percentile	
	Men	Women	Men	Women
1. Weight (Fig. 1)	65.2 Kg (143 lbs)	50 Kg (110 lbs)	101.7 Kg (224 lbs)	80.6 Kg (177 lbs)
2. Stature (Fig. 1)	168.3 (66.3)	156.2 (61.5)	190.9 (75.2)	177.5 (69.9)
3. Eye height (Fig. 2)	156.6 (61.7)	145.3 (57.2)	178.1(70.1)	165.9 (65.3)
4. Shoulder (Acromiale) height (Fig. 2)	138.0 (54.3)	126.8 (49.9)	158.4 (62.4)	147.0 (57.9)
5. Chest (Nipple) height (Fig. 2)	122.4 (48.2)	112.7 (44.4)	141.1 (55.6)	131.1 (51.6)
6. Elbow (Radiale) height (Fig. 2)	106.1 (41.8)	99.9 (39.3)	123.7 (48.7)	114.8 (45.2)
7. Fingertip (Dactylion) height (Fig. 2)	62.9 (24.8)	58.9 (23.2)	76.2 (30.0)	70.8 (27.9)
8. Waist (Iliocristale) height (Fig. 2)	99.1 (39.0)	94.9 (37.4)	119.7 (47.1)	110.9(43.7)
9. Crotch height (Fig. 2)	79.1 (31.1)	71.9 (28.3)	95.6 (37.6)	88.4 (34.8)
10. Knee (Mid-Patella) height (Fig. 2)	49.9 (19.6)	45.5 (17.9)	59.0 (23.2)	54.1 (21.3)
11. Functional (Thumbtip) reach (Fig. 3)	71.7 (28.2)	67.7 (26.7)	88.6 (34.9)	80.5 (31.7)
12. Functional reach, extended (Fig 3)	80.5 (31.7)	73.5 (28.9)	94.2 (37.1)	92.3 (36.3)
13. Overhead reach height (Fig. 3)	200.4 (78.9)	185.3 (73.0)	230.5 (90.8)	215.1 (84.7)

\* Data derived from MIL-HDBK-759, Table 16a. Weights were adjusted from nude body by adding 3.61 kgs (7.97 lbs) for Battle Dress Uniform, underwear, belt and boots. Heights were adjusted from nude body by adding 3.81 cm (1.5 in) for combat boot heel.

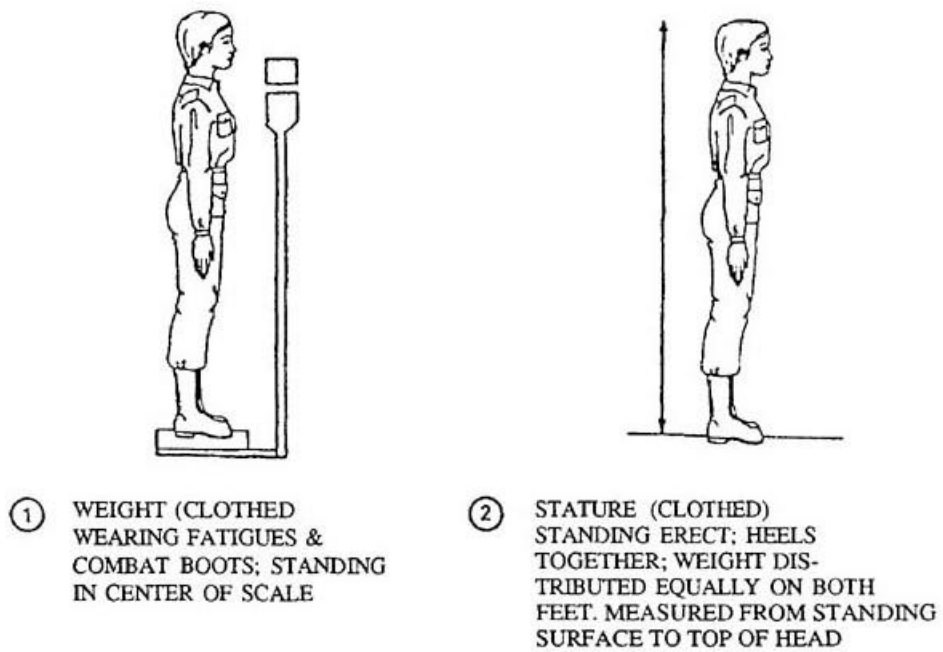


FIGURE 1. Anthropometric data for the standing position, weight and stature

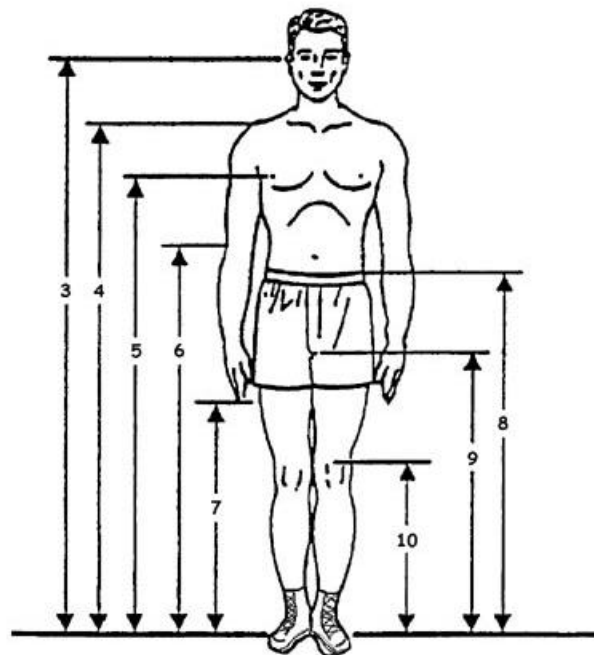
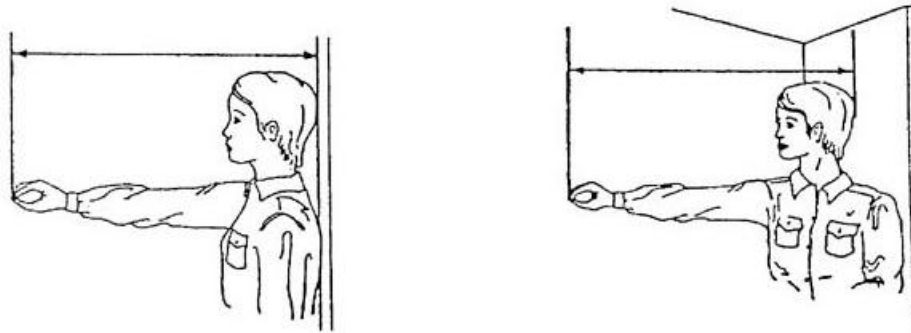
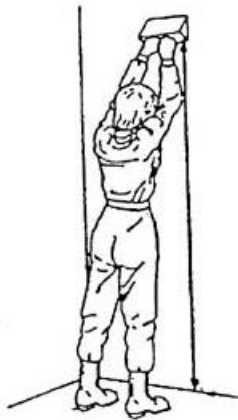


FIGURE 2. Standing body dimensions



⑪ FUNCTIONAL REACH - STANDING ERECT; LOOKING STRAIGHT AHEAD; BOTH SHOULDERS AGAINST WALL; RIGHT ARM HORIZONTAL. MEASURED FROM WALL TO TIP OF THUMB.

⑫ FUNCTIONAL REACH, EXTENDED- STANDING ERECT; LOOKING STRAIGHT AHEAD; RIGHT SHOULDER EXTENDED AS FAR FORWARD AS POSSIBLE WHILE BACK OF LEFT SHOULDER FIRMLY AGAINST WALL; ARM HORIZONTAL. MEASURED FROM WALL TO TIP OF THUMB.



⑬ OVERHEAD REACH HEIGHT - STANDING WITH HEELS 23 cm APART AND TOES 15 cm FROM WALL; ARMS EXTENDED OVER- HEAD WITH FISTS TOUCHING AND AGAINST WALL: 1st PHALANGES HORIZONTAL. MEASURED FROM FLOOR TO HIGHEST POINT ON 1st PHALANGES

FIGURE 3. Standing reach

## D5.2. Body movement.

D5.2.1. Range of motion. Table 2 gives the ranges, in angular degrees, for all voluntary movements the joints of the body can make, as illustrated in Figure 4. The designer should remember that these are maximum values; since they were measured with nude personnel, they do not reflect the restrictions clothing would impose. The lower limit should be used when personnel must operate or

#### **DFP-420**

maintain an item; the upper limit should be used in designing for freedom of movement.

D5.2.2. Whole body. All operating positions should allow enough space to move the trunk of the body. When large forces [more than 13.6 kg (30 lbs)] or large control displacements [more than 380 mm (15 in) in a fore-aft direction] are required, the operator should have enough space to move his entire body.



DFP-420

TABLE II.  
Range of human motion<sup>1</sup>

Body Member	Movement	Lower Limit (degrees)	Average (degrees)	Upper Limit (degrees)
A. Wrist	1. Flexion	78	90	102
	2. Extension	86	99	112
	3. Adduction	18	27	36
	4. Abduction	40	47	54
B. Forearm	1. Supination	91	113	135
	2. Pronation	53	77	101
C. Elbow	1. Flexion	132	142	152
D. Shoulder	1. Lateral Rotation	21	34	47
	2. Medial Rotation	75	97	119
	3. Extension	47	61	75
	4. Flexion	176	188	190
	5. Adduction	39	48	57
	6. Abduction	117	134	151
E. Hip	1. Flexion	100	113	126
	2. Adduction	19	31	43
	3. Abduction	41	53	65
	4. Medial Rotation (prone)	29	39	49
	5. Lateral Rotation (prone)	24	34	44
	6. Lateral Rotation (sitting)	21	30	39
	7. Medial Rotation (sitting)	22	31	40
F. Knee Flexion	1. Prone	115	125	135
	2. Standing	100	113	126
	3. Kneeling	150	159	168

<sup>1</sup>These values are based on the nude body. The ranges are larger than they would be for clothed personnel.

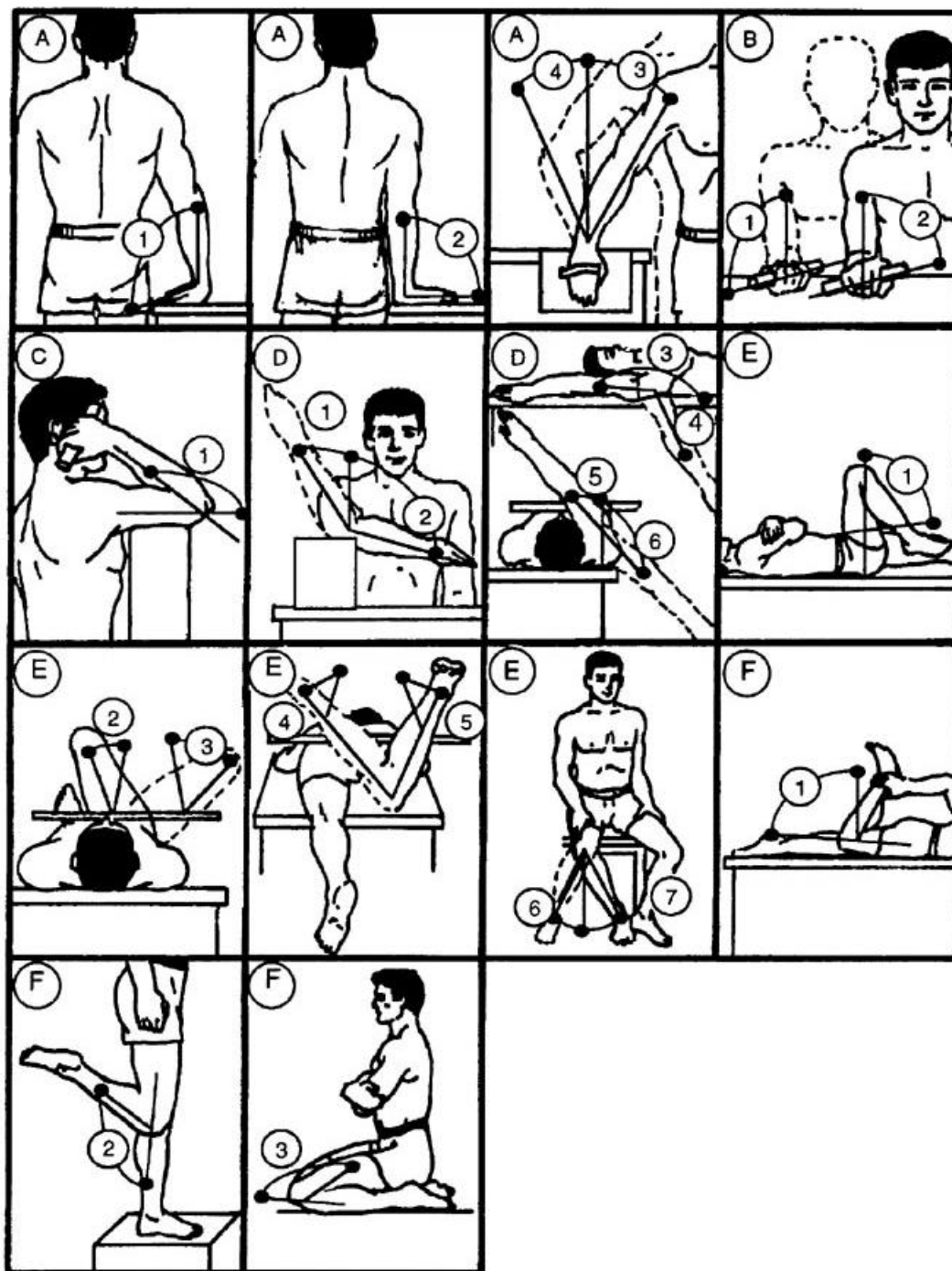


FIGURE 4. Range of human motion

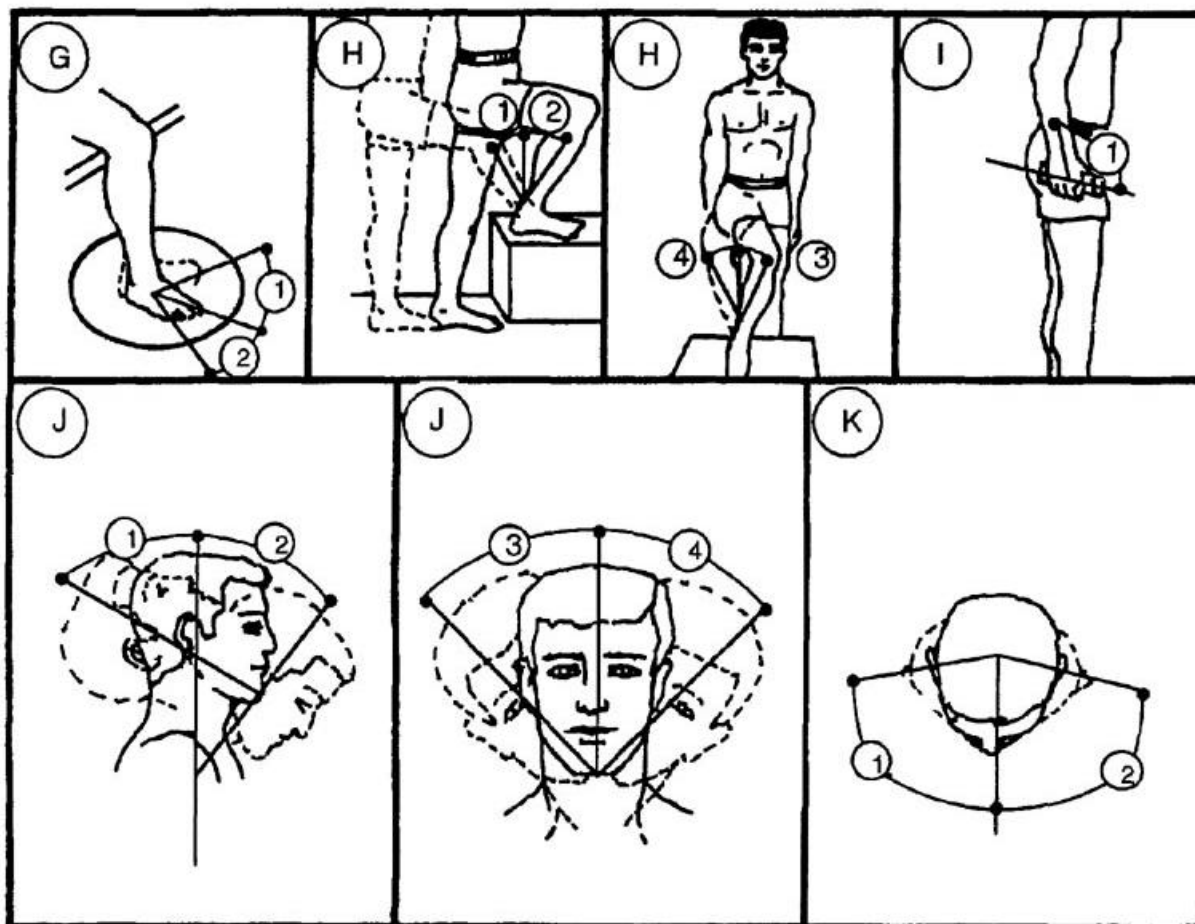


FIGURE 4. Range of human motion - continued

TABLE II.  
Range of human motion - continued<sup>1</sup>

Body Member	Movement	Lower Limit (degrees)	Average (degrees)	Upper Limit (degrees)
G. Foot Rotation	1. Medial	23	35	47
	2. Lateral	31	43	55
H. Ankle	1. Extension	26	38	50
	2. Flexion	28	35	42
	3. Adduction	15	24	33
	4. Abduction	16	23	30
I. Grip Angle		95	102	109
J. Neck Flexion	1. Dorsal (back)	44	61	88
	2. Ventral (forward)	48	60	72
	3. Right	34	41	48
	4. Left	34	41	48
K. Neck Rotation	1. Right	65	79	93
	2. Left	65	79	93

<sup>1</sup>These values are based on the nude body. The ranges are larger than they would be for clothed personnel.

Flexion: Bending or decreasing the angle between parts of the body.

Extension: Straightening or increasing the angle between parts of the body.

Adduction: Moving toward the midline of the body.

Abduction: Moving away from the midline of the body.

Medial Rotation: Turning toward the midplane of the body.

Lateral Rotation: Turning away from the midplane of the body.

Pronation: Rotation of the palm of the hand downward.

Supination: Rotation of the palm of the hand upward.

### D5.3. Push and pull forces.

D5.3.1. Horizontal. Manual horizontal push and pull forces required to be applied or to be sustained over a short period of time should not exceed the values of Table III, as applicable, or those given in Table IV, if more appropriate to the force and movement characteristics of the task.

**DFP-420**

**TABLE III.**

**Horizontal push and pull forces exerable intermittently or for short periods of time**

HORIZONTAL FORCE <sup>1</sup>	APPLIED WITH <sup>2</sup>	CONDITION ( $\mu$ = Coefficient of Friction)
100N (25 lb) push or pull	both hands or one shoulder or the back	Low traction: $0.2 < \mu < 0.3$
200N (45 lb) push or pull	both hands or one shoulder or the back	Medium traction: $\mu \sim 0.6$
300N (70 lb) push or pull	both hands or one shoulder or the back	High traction: $\mu > 0.9$

<sup>1</sup>May be doubled for two and tripled for three operators pushing simultaneously. For the fourth and each additional operator, not more than 75% of their push capability should be added.

<sup>2</sup>See figure 5 for examples.

Note: Values are predicated upon a suitable surface for force exertion, i.e., a vertical, rough surface, approximately 40 cm (16 in) wide, and 510 - 127 cm (20 - 50 in) above the floor to allow force application with the hands, the shoulder, or the back.

This table is an excerpt of MIL-STD-1472, Table XXIV. The data are normally considered to apply to the male population only. Here they are applied to the female population as well, on the presumption that females meeting the strength requirements for Maintenance Workers will of necessity have a body mass at least equal to that of the 5<sup>th</sup> percentile male in the general population.

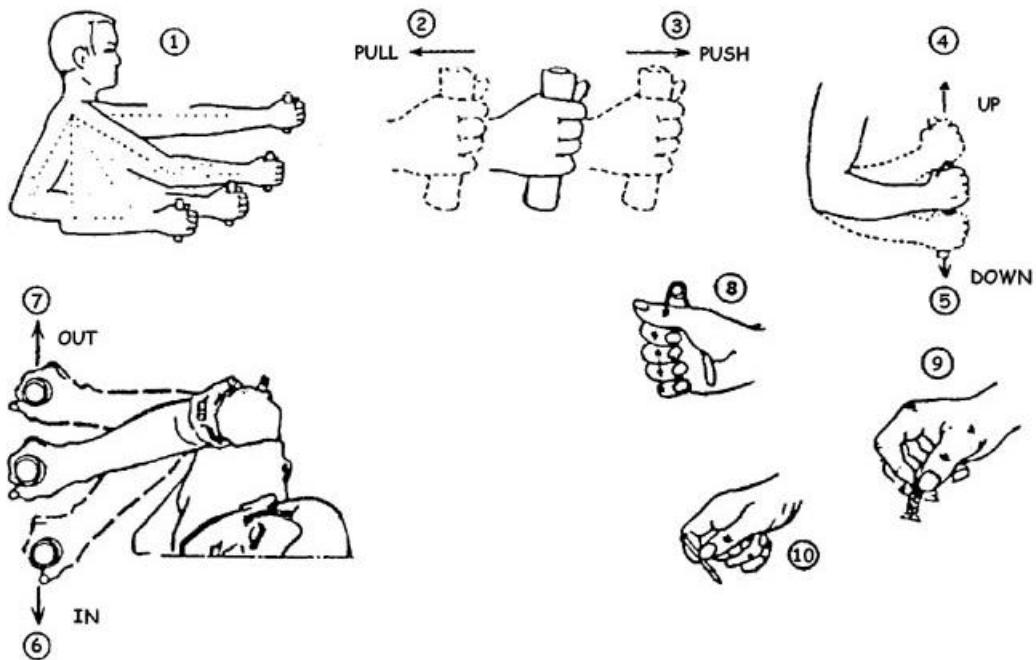
## DFP-420

LOW/MEDIUM/HIGH TRACTION



FIGURE 5. Examples of push force conditions for Table III

# DFP-420



ARM STRENGTH (N)												
(1)	(2)		(3)		(4)		(5)		(6)		(7)	
DEGREE OF ELBOW FLEXION (deg)	PULL		PUSH		UP		DOWN		IN		OUT	
	L*	R*	L	R	L	R	L	R	L	R	L	R
180	222	231	187	222	40	62	58	76	58	89	36	62
150	187	249	133	187	67	80	80	89	67	89	36	67
120	151	187	116	160	76	107	93	116	89	98	45	67
90	142	165	98	160	76	89	93	116	71	80	45	71
60	116	107	98	151	67	89	80	89	76	89	53	76
HAND, AND THUMB-FINGER STRENGTH (N)												
	(8)		(9)		(10)							
	HAND GRIP		THUMB-FINGER GRIP (PALMER)		THUMB-FINGER GRIP (TIPS)							
	L	R										
MOMENTARY HOLD	250	260	60		60							
SUSTAINED HOLD	145	155	35		35							

\* L = LEFT; R = RIGHT

## DFP-420

TABLE IV. Arm, hand and thumb-finger strength (5<sup>th</sup> percentile male data)

D5.3.2. Vertical. Manual vertical push and pull forces required should not exceed the applicable fifth percentile peak or mean force values cited for men in Table V, or those given in Figure 6, if more appropriate to the force and movement characteristics of the task.

Table V.

### Static Muscle Strength Data

Strength measurements	Percentile Values in Newtons (Pounds)			
	5 <sup>th</sup> Percentile		95 <sup>th</sup> Percentile	
	Men	Women	Men	Women



# DFP-420

(see Figure 6)				
A Standing two-handed pull:				
38 cm level				
Mean force	738(166)	331(74)	1354(304)	818(184)
Peak force	845(190)	397(89)	1437(323)	888(200)
B Standing two-handed pull:				
50 cm level				
Mean force	758(170)	326(73)	1342(302)	841(189)
Peak force	831(187)	374(84)	1442(324)	905(203)
C Standing two-handed pull:				
100 cm level				
Mean force	444(100)	185(42)	921(209)	443(100)
Peak force	504(113)	218(49)	988(222)	493(111)
D Standing two-handed push:				
150 cm level				
Mean force	409(92)	153(34)	1017(229)	380(85)
Peak force	473(106)	188(42)	1094(246)	430(97)
E Standing one-handed pull:				
100 cm level				
Mean force	215(48)	103(23)	628(141)	284(64)
Peak force	259(58)	132(30)	724(163)	322(72)

## DFP-420



- A. STANDING TWO-HANDED PULL: 38 cm (15") LEVEL  
STANDING WITH FEET 45 cm (18") APART AND KNEES BENT. BENDING AT WAIST, GRASPING BOTH SIDES, OF 45 cm (18") LONG HANDLE LOCATED DIRECTLY IN FRONT, 38 cm (15") ABOVE STANDING SURFACE, AND PULLING, USING PRIMARILY ARMS, SHOULDERS AND LEGS.



- B. STANDING TWO-HANDED PULL: 50 cm (20") LEVEL  
STANDING WITH FEET 45 cm (18") APART AND KNEES STRAIGHT. BENDING AT WAIST, GRASPING BOTH SIDES OF 45 cm (18") LONG HANDLE LOCATED DIRECTLY IN FRONT, 50 cm (20") ABOVE STANDING SURFACE, AND PULLING, USING PRIMARILY ARMS AND SHOULDERS.



- C. STANDING TWO-HANDED PULL: 100 cm (39") LEVEL  
STANDING ERECT WITH FEET 45 cm (18") APART, GRASPING BOTH SIDES OF 45 cm (18") LONG HANDLE LOCATED DIRECTLY IN FRONT, 100 cm (39") ABOVE STANDING SURFACE, AND PULLING, USING THE ARMS.



- D. STANDING TWO-HANDED PUSH: 150 cm (59") LEVEL  
STANDING ERECT WITH FEET 45 cm (18") APART, GRASPING FROM BELOW, BOTH SIDES OF 45 cm (18") LONG HANDLE LOCATED DIRECTLY IN FRONT, 150 cm (59") ABOVE STANDING SURFACE. PUSHING UPWARD USING ARMS AND SHOULDERS.



- E. STANDING ONE-HANDED PULL: 100 cm (39") LEVEL  
STANDING ERECT WITH FEET 15 cm (6") APART, DOMINANT HAND GRASPING UNDERSIDE OF D-RING LOCATED DIRECTLY TO THE SIDE, 100 cm (39") ABOVE STANDING SURFACE. PULLING UPWARD WHILE KEEPING SHOULDER SQUARE AND OTHER ARM RELAXED AT SIDE.

FIGURE 6. Static muscle strength data

D5.4. Weight.

## DFP-420

D5.4.1. Lifting limits. The weight limits in Table VI, conditions A and B, should be used as maximum values in determining the design weight of items requiring one person lifting with two hands. The weight limits in Table VI plus 18 kg (40 lb) should be used as the maximum values in determining the design weight of items requiring two person lifting, provided the load is uniformly distributed between the two lifters. If the weight of the load is not uniformly distributed, the weight limit of Table VI applies to the heavier lift point. Where three or more persons are lifting simultaneously, not more than 14 kg (30 lb) may be added for each additional lifter, provided that the object lifted is sufficiently large that the lifters do not interfere with one another while lifting. Where it is not possible to define the height to which an object will be lifted in operational use, the limit wherein the object is lifted to shoulder height should be used rather than the more permissive bench height value. The values in Table V are applicable to objects with or without handles.

TABLE VI.  
Design weight limits

HANDLING FUNCTION	POPULATION*
	Male and Female
A. Lift an object from the floor and place it on a surface not greater than 152 cm (5 ft) above the floor.	36.4 kg (80 lb)
B. Lift an object from the floor and place it on a surface not greater than 91 cm (3 ft) above the floor.	53.6 kg (110 lb)
C. Carry an object 7.6 m (25 ft) or less.	53.6 kg (70 lb)

\* Data from MIL-STD-1472 adjusted to reflect the physical requirements for Mechanics and Repairers, Military Occupational Specialty (MOS) 62 & 63 Series, in accordance with MIL-STD-1472 paragraph 1.4 and DA PAM 611-21.

D5.4.2. Load size. The maximum permissible weight lift limits in Table V apply to an object with uniform mass distribution and a compact size not exceeding 46 cm (18 in) high, 46 cm (18 in)

## DFP-420

wide, and 30 cm (12 in) deep (away from the lifter). This places the handholds at half the depth, or 15 cm (6 in) away from the body. If the depth of the object exceeds 61 cm (24 in) the permissible weight should be reduced by 33 percent. If the depth of the object exceeds 91 cm (36 in), the permissible weight should be reduced by 50 percent. If the depth of the object exceeds 122 cm (48 in), the permissible weight should be reduced by 66 percent.

D5.4.3. Obstacles. The values in Table V assume that there are no obstacles between the person lifting and the shelf, table, bench or other surface on which the object is to be placed. Where a lower protruding shelf or other obstacle limits the lifter's approach to the desired surface, the weight limit of the object should be reduced by 33 percent

D5.4.4. Carrying limits. The weight limit in Table V condition C should be used as the maximum value in determining the design weight of items requiring one person carrying of objects a distance of up to 7.6 m (25 ft). The maximum permissible weight for carrying an object with a handle on top, such as a tool box, which usually is carried at the side with one hand, is 36 kg (80 lbs). The one-person weight carrying limit plus 18 kg (40 lbs) should be used as the maximum value in determining the design weight of items requiring two-person carrying, provided the load is uniformly distributed between the two carriers. Where three or more persons are carrying a load together, not more than 14 kg (30 lbs) may be added for each additional person, provided that the object is sufficiently large that the workers do not interfere with one another while carrying the load. In all cases involving carrying, it is assumed that the object is first lifted from the floor, carried a distance of 7.6 m (25 ft) or less, and placed on the floor or on another surface not higher than 91 cm (36 in). If the final lift is to a higher height, the 152 cm (5 ft) lift height applies as the more limiting case.

D5.4.5. Object carry size. The reduction formula expressed in paragraph B5.3.2 should be applied to size of objects to be carried in the same manner as for load size.

D5.4.6. Labeling. Items weighing more than 18 kg (40 lb) should be prominently labeled with the weight of the object. Where mechanical or power lift is required, hoist and lift points should be provided and clearly labeled.

### D5.5. Handles and grasp areas.

D5.5.1. General. All items designed to be carried or removed and replaced should be provided with handles or other suitable means for grasping, handling, and carrying by a gloved or mittened hand. Items requiring handling should be provided with not less than two handles or one handle and one grasp area. Items weighing less than 4.5 kg (10 lb) whose form factor permits them to be handled easily should be exempt from this requirement.

D5.5.2. Location. Whenever possible, handles, grasp areas, or hoist points should be located above the center of gravity and in a manner to preclude uncontrolled swinging or tilting when lifted. They should be located to provide at least 5 cm (2 in) of clearance from obstructions during handling. The location of handles should not interfere with installing, removing, operating, or maintaining the equipment.

D5.5.3. Nonfixed handles. Nonfixed handles (e.g., hinged or fold-out) should have a stop

## **DFP-420**

position for holding the handle perpendicular to the surface on which it is mounted and should be capable of being placed into carrying position by one hand (where appropriate, by a gloved or mittened hand).

D5.5.4. Grasp surface. Where an item's installation requires that its bottom surface be used as a handhold during removal or installation, a nonslip grasp surface (e.g., grooved, knurled, or frictional) should be provided.

# DFP-420

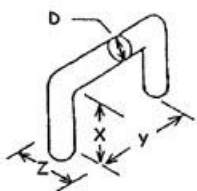
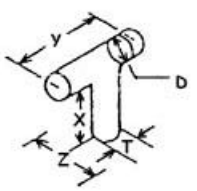
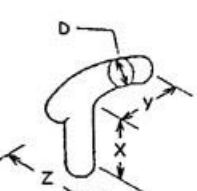
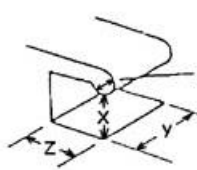
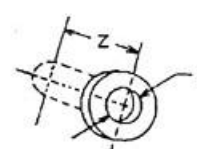
ILLUSTRATION	TYPE OF HANDLE	DIMENSIONS IN mm (in inches)																																																	
		'Bare Hand)			(Gloved Hand)			(Mittened Hand)																																											
		X	Y	Z	X	Y	Z	X	Y	Z																																									
	Two-finger bar	32 (1-1/4)	65 (2-1/2)	75 (3)	38 (1-1/2)	75 (3)	75 (3)	Not Applicable																																											
	One-hand bar	48 (1-7/8)	111 (4-3/8)	75 (3)	50 (2)	125 (5)	100 (4)	75 (3)	135 (5-1/4)	150 (6)																																									
	Two-hand bar	48 (1-7/8)	215 (8-1/2)	75 (3)	50 (2)	270 (10-1/2)	100 (4)	75 (3)	280 (11)	150 (6)																																									
	T-bar	38 (1-1/2)	100 (4)	75 (3)	50 (2)	115 (4-1/2)	100 (4)	Not Applicable																																											
	J-bar	50 (2)	100 (4)	75 (3)	50 (2)	115 (4-1/2)	100 (4)	75 (3)	125 (5)	150 (6)																																									
	Two-finger recess	32 (1-1/4)	65 (2-1/2)	50 (2)	38 (1-1/2)	75 (3)	50 (2)	Not Applicable																																											
	One-hand recess	50 (2)	110 (4-1/4)	90 (3-1/2)	90 (3-1/2)	135 (5-1/4)	100 (4)	90 (3-1/2)	135 (5-1/4)	125 (5)																																									
	Finger-tip recess	19 (3/4)	—	13 (1/2)	25 (1)	—	19 (3/4)	Not Applicable																																											
	One-finger recess	32 (1-1/4)	—	50 (2)	38 (1-1/2)	—	50 (2)	Not Applicable																																											
<table><tr><td rowspan="6">Curvature of Handle or Edge  (DOES NOT PRECLUDE USE OF OVAL HANDLES)</td><td colspan="3">Weight of Item</td><td colspan="3">Minimum Diameter</td><td colspan="4" rowspan="6">Gripping efficiency is best if finger can curl around handle or edge to any angle of <math>\frac{2}{3} \pi</math> rad (120°) or more.</td></tr><tr><td colspan="3">Up to 6.8 kg (up to 15 lbs)</td><td colspan="3">D - 6 mm (1/4 in)</td></tr><tr><td colspan="3">6.8 to 9.0 kg (15 to 20 lbs)</td><td colspan="3">D - 13 mm (1/2 in)</td></tr><tr><td colspan="3">9.0 to 18 kg (20 to 40 lbs)</td><td colspan="3">D - 19 mm (3/4 in)</td></tr><tr><td colspan="3">Over 18 kg (over 40 lbs)</td><td colspan="3">D - 25 mm (1 in)</td></tr><tr><td colspan="3">T-bar Post</td><td colspan="3">T - 13mm (1/2 in)</td></tr></table>											Curvature of Handle or Edge  (DOES NOT PRECLUDE USE OF OVAL HANDLES)	Weight of Item			Minimum Diameter			Gripping efficiency is best if finger can curl around handle or edge to any angle of $\frac{2}{3} \pi$ rad (120°) or more.				Up to 6.8 kg (up to 15 lbs)			D - 6 mm (1/4 in)			6.8 to 9.0 kg (15 to 20 lbs)			D - 13 mm (1/2 in)			9.0 to 18 kg (20 to 40 lbs)			D - 19 mm (3/4 in)			Over 18 kg (over 40 lbs)			D - 25 mm (1 in)			T-bar Post			T - 13mm (1/2 in)		
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Table VII. Minimum handle dimensions

## DFP-420

D5.5.5. Handle dimensions. Handles that are to be used with mittened, gloved, or ungloved hands should equal or exceed the minimum applicable dimensions shown in Table VII.

D5.5.6. Handle and grasp area force requirements. Force requirements to operate handle and grasp areas should not exceed the values in Table IV.

D5.5.7. Handle material. Handles or grasp areas used with bare hands should have surfaces that are not thermally (see thermal contact hazards paragraph) or electrically conductive. The surface should be sufficiently hard to prevent embedding of grit and grime during normal use.

D5.6. Vibration. Equipment oscillations should not impair human performance with respect to control manipulations or the readability of numerals or letters. Equipment vibrations in the range of 1 to 4 Hz having an acceleration greater than 8 feet per second (rms) should be avoided.

### D5.7. Storage.

#### D5.7.1. General.

D5.7.1.1 Standardization. Standard containers should be used whenever practicable and should meet the human engineering criteria herein.

D5.7.1.2 Ease of replacement. Equipment should be configured for removal and replacement by one person where permitted by structural, functional, and weight limitations.

D5.7.1.3 Clothing constraints. Equipment should be capable of being removed and replaced by personnel wearing personal protective and special purpose clothing and equipment, including NBC protective clothing in an NBC contaminated environment.

D5.7.1.4 Removal. Stored items should be removable along a straight or slightly curved line, rather than through an angle.

D5.7.1.5 Limit stops. Limit stops should be provided on drawers. Drawers should be self-locking in the retracted and extended positions. The limit stop design should permit convenient overriding of stops for drawer removal.

D5.7.1.6 Covers or panels. Removal of any stored item should require opening or removing a minimum number of covers.

#### D5.7.2. Mounting of items within units.

D5.7.2.1 Similar items. Similar items and containers should utilize a common mounting design and orientation within the unit. Similar items and containers should be made distinguishable by labeling, color coding, or marking.

D5.7.2.2 Delicate items. Components susceptible to personnel-induced damage (e.g., rough handling, abrasion, or contamination) should be clearly identified and guarded from abuse both

## DFP-420

physically and procedurally.

### D5.7.3. Accessibility.

D5.7.3.1 Structural members. Structural members or permanently installed equipment should not visually or physically obstruct removal and replacement of stored equipment. Equipment restraining devices should be directly visible and physically accessible to the user.

D5.7.3.2 Large items. Large items which are difficult to remove should be so mounted that they will not prevent convenient access to other items.

D5.7.3.3 Relative accessibility. Items requiring most frequent access should be most accessible.

### D5.7.4. Storage containers.

D5.7.4.1 Securing of covers. It should be obvious when a storage container door or lid is not secured, even though it may be in place.

D5.7.4.2 Instructions. If the method of opening a storage container is not obvious from the construction of the container itself, instructions should be permanently displayed on the outside of the container. Instructions should consist of simple symbols such as arrows or simple words such as “push” or “push and turn.”

D5.7.4.3 Clearance. Bulkheads, brackets, and other equipment should not obstruct visual or physical access for removal, replacement, or opening of storage containers. Covers, doors or panels which must be opened to remove or replace equipment and supplies should be visually and physically accessible to the user.

D5.7.4.4 Self-supporting covers. Hinged lids and doors should be self-supporting in the open position. The cover in the open position should not obstruct required visual or physical access to the stored equipment. Self-supporting covers should be capable of being opened and closed with one hand.

D5.7.4.5 Labeling. Each storage container should be labeled with nomenclature for the items it contains. Accesses should be labeled with warning signs disclosing any hazards existing within the storage area and prescribing precautions. Opening or removing an access cover should not remove or visually obstruct any hazard warning.

D5.7.4.6 Rounding. Cover and access edges should be rounded (See safety paragraph on edge rounding) to preclude hand injury or clothing damage.

### D5.7.5. Physical access.

D5.7.5.1 Arm and hand access. Openings provided for access to stored equipment should be sized to permit the required handling and should provide an adequate view of the item being manipulated. All blind arm and hand access should require approval of the procuring activity.

D5.7.5.1.1. Opening covers. Access covers should be equipped with grasp areas or other



## DFP-420

means for opening them. Covers should accommodate handwear or special clothing that may be worn by the maintainer.

D5.7.5.1.2. Reach access dimensions and shape. The dimensions of access openings should be not less than those shown in Table VIII. Allowance should be made for the clearance of the operator's hand, applicable handwear, and clothing. Access shape should provide clearance for the equipment (including its protuberances, attachments and handles) that the user must pass through the opening, appropriate body parts, and tools.

D5.7.5.1.3. Guarding hazardous conditions. If a hazardous condition exists behind the access, the presence of the hazard should be noted on the cover such that it remains visible when the access is open.

D5.7.5.1.4. Type of opening. Where equipment storage is required, the following practices should be followed in order of preference: a. An opening with no cover unless this is likely to degrade system performance, security, safety, or NBC contamination survivability. b. A hand-operated (sliding or hinged) lid or door. c. A hand-operated latched lid .

D5.7.5.2 Access cover attachment. Covers should be secured with the fewest number of simplest-to-operate latches practicable. Latches should be operable by hand. Small, removable covers should be attached to the structure or otherwise retained to prevent loss.

D5.7.6. Attachments. Connected appurtenances, accessories, cables, hoses, and similar items should not interfere with removing, replacing, or carrying a stored item. If such connected appurtenances interfere with these tasks, they should be easily removed or disconnected from the equipment before handling. Easy disconnect should consist of hand operable quick disconnect or standard hand tool operable disconnects in that order of preference.

# DFP-420

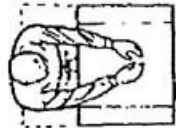

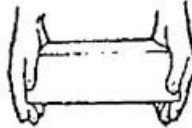








MINIMAL TWO-HAND ACCESS OPENINGS WITHOUT VISUAL ACCESS																																																	
<p><u>Reaching with both hands to depth of 150 to 490mm:</u></p> <p>Light clothing: Width: 200mm or the depth of reach* Height: 125mm</p> <p>Arctic clothing: Width: 150mm plus 3/4 the depth of reach Height: 180mm</p> <p><u>Reaching full arm's length (to shoulders) with both arms:</u></p> <p>Width: 500mm Height: 125mm</p> <p><u>Inserting box grasped by handles on the front:</u></p> <p>13mm clearance around box, assuming adequate clearance around handles</p> <p><u>Inserting box with hands on the sides:</u></p> <p>Light clothing: Width: Box plus 115mm ‡ Height: 125mm or 13mm around box*</p> <p>Arctic clothing: Width: Box plus 180mm ‡ Height: 215mm or 15mm around box*</p> <p>*Whichever is larger. ‡If hands curl around bottom, allow an extra 38mm for light clothing, 75mm for arctic clothing.</p>			  																																														
MINIMAL ONE-HAND ACCESS OPENINGS WITHOUT VISUAL ACCESS																																																	
<p><u>Empty hand, to wrist:</u></p> <table border="1"> <thead> <tr> <th></th> <th>Height</th> <th>Width</th> </tr> </thead> <tbody> <tr> <td>Bare hand, rolled:</td> <td>95mm</td> <td>sq or dia</td> </tr> <tr> <td>Bare hand, flat:</td> <td>55mm</td> <td>x 100mm or 100mm dia</td> </tr> <tr> <td>Glove or mitten:</td> <td>100mm</td> <td>x 150mm or 150mm dia</td> </tr> <tr> <td>Arctic mitten:</td> <td>125mm</td> <td>x 165mm or 165mm dia</td> </tr> </tbody> </table> <p><u>Clenched hand to wrist:</u></p> <table border="1"> <tbody> <tr> <td>Bare hand:</td> <td>95mm</td> <td>x 125mm or 125mm dia</td> </tr> <tr> <td>Glove or mitten:</td> <td>115mm</td> <td>x 150mm or 150mm dia</td> </tr> <tr> <td>Arctic mitten:</td> <td>180mm</td> <td>x 215mm or 215mm dia</td> </tr> </tbody> </table> <p><u>Hand plus 1" dia object, to wrist:</u></p> <table border="1"> <tbody> <tr> <td>Bare hand:</td> <td>95mm sq or dia</td> </tr> <tr> <td>Gloved hand:</td> <td>150mm sq or dia</td> </tr> <tr> <td>Arctic mitten:</td> <td>180mm sq or dia</td> </tr> </tbody> </table> <p><u>Hand plus object over 1" in dia, to wrist:</u></p> <table border="1"> <tbody> <tr> <td>Bare hand:</td> <td>45mm clearance around object</td> </tr> <tr> <td>Glove or mitten:</td> <td>65mm clearance around object</td> </tr> <tr> <td>Arctic mitten:</td> <td>90mm clearance around object</td> </tr> </tbody> </table> <p><u>Arm to elbow:</u></p> <table border="1"> <tbody> <tr> <td>Light clothing:</td> <td>100mm x 115mm</td> </tr> <tr> <td>Arctic clothing:</td> <td>180mm sq or dia</td> </tr> <tr> <td>With object:</td> <td>Clearances as above</td> </tr> </tbody> </table> <p><u>Arm to shoulder:</u></p> <table border="1"> <tbody> <tr> <td>Light clothing:</td> <td>125mm sq or dia</td> </tr> <tr> <td>Arctic clothing:</td> <td>215mm sq or dia</td> </tr> <tr> <td>With object:</td> <td>Clearances as above</td> </tr> </tbody> </table>		Height	Width	Bare hand, rolled:	95mm	sq or dia	Bare hand, flat:	55mm	x 100mm or 100mm dia	Glove or mitten:	100mm	x 150mm or 150mm dia	Arctic mitten:	125mm	x 165mm or 165mm dia	Bare hand:	95mm	x 125mm or 125mm dia	Glove or mitten:	115mm	x 150mm or 150mm dia	Arctic mitten:	180mm	x 215mm or 215mm dia	Bare hand:	95mm sq or dia	Gloved hand:	150mm sq or dia	Arctic mitten:	180mm sq or dia	Bare hand:	45mm clearance around object	Glove or mitten:	65mm clearance around object	Arctic mitten:	90mm clearance around object	Light clothing:	100mm x 115mm	Arctic clothing:	180mm sq or dia	With object:	Clearances as above	Light clothing:	125mm sq or dia	Arctic clothing:	215mm sq or dia	With object:	Clearances as above	     
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<p><u>Push button access:</u></p> <table border="1"> <tbody> <tr> <td>Bare hand:</td> <td>32mm dia</td> </tr> <tr> <td>Gloved hand:</td> <td>38mm dia</td> </tr> </tbody> </table> <p><u>Two finger twist access:</u></p> <table border="1"> <tbody> <tr> <td>Bare hand:</td> <td>object plus 50mm</td> </tr> <tr> <td>Gloved hand:</td> <td>object plus 65mm</td> </tr> </tbody> </table>	Bare hand:	32mm dia	Gloved hand:	38mm dia	Bare hand:	object plus 50mm	Gloved hand:	object plus 65mm	 																																								
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TABLE VIII. Arm and hand access dimensions

## DFP-420

### D5.8. Design for maintainer.

#### D5.8.1. General.

D5.8.1.1 Standardization. Standard parts should be used whenever practicable and should meet the human engineering criteria herein.

D5.8.1.2 Special tools. Special tools should be used only when common hand tools cannot be used, when they provide significant advantage over common hand tools, or where required by security considerations. Special tools required for operational adjustment maintenance should be securely mounted within the equipment in a readily accessible location.

D5.8.1.3 Ease of replacement. Equipment should be configured for removal and replacement by one person where permitted by structural, functional, and weight limitations.

D5.8.1.4 Assembly and disassembly. Equipment should be capable of being assembled and disassembled in its operational environment by a minimum number of trained personnel wearing clothing appropriate to the operating environment specified for the system maintenance concept.

D5.8.1.5 Clothing constraints. Equipment should be capable of being removed, replaced, and repaired by personnel wearing personal protective and special purpose clothing and equipment appropriate to the maintenance concept, including NBC protective clothing in an NBC contaminated environment.

D5.8.1.6 Error-proof design. Improper mounting and installation (including interchange of items of a same or similar form that are not in fact functionally interchangeable) should be prevented by physical measures to ensure proper mounting of items (e.g., alignment devices).

#### D5.8.2. Mounting of items within units.

D5.8.2.1 Similar items. Similar items should utilize a common mounting design and orientation within the unit. This mounting design should preclude interchange of items which are not functionally interchangeable. Similar items that are not functionally interchangeable should be made distinguishable by labeling, color-coding, or marking to prevent unwanted substitution.

D5.8.2.2 Delicate items. Components susceptible to maintenance-induced damage e.g., rough handling, abrasion, contamination) should be clearly identified and guarded from abuse both physically and procedurally.

#### D5.8.3. Accessibility.

D5.8.3.1 Structural members. Structural members or permanently installed equipment should not visually or physically obstruct adjustment, servicing, removal of replaceable equipment, or other required maintenance tasks. Panels, cases, and covers removed to access equipment should have the same access requirements as replaceable equipment. Mounting provisions should be directly visible and physically accessible to the maintainers.

D5.8.3.2 Large items. Large items which are difficult to remove should be so mounted that they will not prevent convenient access to other items.

## DFP-420

D5.8.3.3 Use of tools and test equipment. Check points, adjustment points, test points, cables, connectors, and labels should be accessible and visible during maintenance. Sufficient space should be provided for the use of test equipment and other required tools without difficulty or hazard.

D5.8.3.4 Relative accessibility. Items requiring most frequent access should be most accessible.

D5.8.3.5 High-failure-rate items. High-failure-rate items should be accessible for replacement without moving non-failed items. Mechanical replacement items should be removable with common hand tools and simple handling equipment.

### D5.8.4. Lubrication.

D5.8.4.1. General. Configuration of equipment requiring lubrication should permit lubrication and, as applicable, checking of lubricant reservoir levels without disassembly. Extended fittings should be provided to lubricant ports that would not otherwise be readily accessible or visible.

D5.8.4.2. Labeling. Where lubrication is required, the type of lubricant to be used and the frequency of lubrication should be specified by a label mounted at or near the lube port or grease fitting. A lubrication chart of permanent construction should be mounted at the operator station of the equipment; individual labels should not be required when the equipment has only one type of fitting and uses only one type of lubricant.

### D5.8.5. Covers.

D5.8.5.1. Case and cover mounting. Cover or shield holes should be large enough for mounting screw clearance without perfect case alignment.

D5.8.5.2. Securing of covers. It should be made obvious when a cover is not secured, even though it may be in place.

D5.8.5.3. Instructions. If the method of opening a cover is not obvious from the construction of the cover itself, instructions should be permanently displayed on the outside of the cover. Instructions should consist of simple symbols such as arrows or simple words such as “push” or “push and turn.”

D5.8.5.4. Clearance. Bulkheads, brackets, and other equipment should not obstruct visual or physical access for removal or opening of covers on equipment within which work must be performed in the installed condition. Covers, doors or panels which must be opened to perform on-site maintenance should be visually and physically accessible to the maintainers.

### D5.8.6. Access openings and covers.

D5.8.6.1. Application. An access should be provided if frequent maintenance would otherwise require removing a case or covering, or dismantling an item of equipment.

D5.8.6.2. Self-supporting covers. Hinged access covers that are not completely removable should be self-supporting in the open position. The cover in the open position should not obstruct required visual or physical access to the equipment being maintained or to related equipment during maintenance. Self-supporting covers should be capable of being opened and closed with one hand.

## DFP-420

D5.8.6.3. Labeling. Each access should be labeled with nomenclature for items visible or accessible through it. Accesses should be labeled with warning signs, disclosing any hazards existing beyond the access and prescribing precautions. Opening or removing an access cover should not remove or visually obstruct any hazard warning. If instructions applying to a covered item appear on a hinged door, the lettering should be oriented to be read when the door is open.

D5.8.6.4. Rounding. Cover and access edges should be rounded (See safety paragraph on edge rounding) to preclude hand injury or clothing damage.

### D5.8.7. Physical access.

D5.8.7.1. Arm and hand access. Openings provided for access to interior equipment should be sized to permit the required adjustment or handling and should provide an adequate view of the item being manipulated. All blind arm and hand access should require approval of the procuring activity.

D5.8.7.1.1. Opening covers. Access covers should be equipped with grasp areas or other means for opening them. Covers should accommodate handwear or special clothing that may be worn by the maintainer.

D5.8.7.1.2. Reach access dimensions and shape. The dimensions of access openings should be not less than those shown in Figure 9. Allowance should be made for the clearance of the operator's hand, applicable handwear, and clothing. Access shape should provide clearance for the equipment (including its protuberances, attachments and handles) that the maintainer must replace through the opening, appropriate body parts, and tools.

D5.8.7.1.3. Tool access dimensions. Access openings should be large enough to operate tools required for maintenance of the equipment reached through the access.

D5.8.7.1.4. Guarding hazardous conditions. If a hazardous condition (such as exposed, high voltage conductors) exists behind the access, the physical barrier over the access should be equipped with an interlock that will de-energize the hazardous equipment when the barrier is open or removed. Both the presence of the hazard and the fact that an interlock exists should be noted on the equipment case or cover such that it remains visible when the access is open. Also see 5.9.9.3.

D5.8.7.1.5. Type of opening. Where physical access is required, the following practices should be followed in order of preference: a. An opening with no cover unless this is likely to degrade system performance, safety, or NBC contamination survivability. b. A hand operated (latched, sliding, or hinged) cap or door where dirt, moisture, or other foreign materials might otherwise create a problem. c. A quick-opening cover plate using ¼ turn captive fasteners if a cap will not meet stress requirements or space prevents a hinged cover. d. A screw-down cover, when captive fasteners cannot be used because of stress, structure, or pressurization constraints. Use minimum number of interchangeable screws to fasten door.

D5.8.7.2. Whole body access. Where whole body access is required, the opening should accommodate 95% of projected maintenance.

D5.8.7.3. Access cover attachment. Covers should be attached with the fewest number of

## DFP-420

simplest-to-operate fasteners practicable. Fasteners should be operable by hand or by common hand tools in that order of preference. Small, removable covers should be attached to the structure or otherwise retained to prevent loss.

### D5.8.8. Fasteners.

D5.8.8.1. General. The number and diversity of fasteners used should be minimized commensurate with stress, bonding, pressurization, shielding, thermal, and safety requirements. When more than one size or type fastener is used on the same equipment or cover, the fasteners-equipment-cover interface should permit the maintainer to readily distinguish the intended location of each fastener. Finger or hand-operated fasteners should be used when consistent with these requirements. Fasteners requiring non-standard tools should not be used.

D5.8.8.2. Hinges and tongue-and-slot catches. Hinges, tongue-and-slot catches and mounting pins should be used to minimize the number of fasteners required.

D5.8.8.3. Captive fasteners. Captive fasteners should be used where dropping or losing such items could cause damage to equipment or create a difficult or hazardous removal problem. Captive fasteners should also be provided for access covers requiring frequent removal.

D5.8.8.4. Quantity. If a hinged access panel or quick-opening fasteners will not meet stress or safety requirements, the minimum number of fasteners consistent with these requirements should be used.

### D5.8.8.5. Fastener head type.

D5.8.8.5.1. High-torque fasteners. External hex or external double-hex wrenching elements should be provided on all machine screws, bolts or other fasteners requiring more than 14 N•m (10 lbf•ft) of torque. When external wrenching fasteners cannot meet the mechanical function or personnel safety requirements, or in limited access situations, and where use is protected from accumulation of foreign material, internal wrenching fasteners may be used. Direct tool access should be provided to allow for torquing without the use of irregular extensions.

D5.8.8.5.2. Low-torque fasteners. External-hex wrenching head, internal-hex wrenching head, combination head (internal-hex or straight recess and external-hex wrenching head), or Torq-set fasteners, should be provided where less than 14 N•m (10 lbf•ft) torque is required. Internal-wrenching fasteners should be provided only where a straight, or convex, smooth surface is required for mechanical function or personnel safety, and where use is protected from accumulation of foreign material (e.g., ice, snow). Straight-slot or cross-recess type internal grip fasteners should not be provided, except as wood fasteners or where these type fasteners are provided on standard commercial items.

D5.8.8.5.3. Common fasteners. Whenever possible, identical screw and bolt heads should be provided to allow panels and components to be removed with one tool. Combination bolt heads such as slotted hex head should be selected whenever feasible. Identical fasteners should not be used where removal of wrong fastener can result in equipment damage or change to calibration settings.

## DFP-420

D5.8.8.6. Accessibility. The heads of mounting bolts and fasteners should be located on surfaces readily accessible to the maintainer. Both hand and tool access should be provided to the unthreaded or loosened fastener.

D5.8.8.7. Number of turns. Fasteners for mounting assemblies and subassemblies should require a minimum number of turns, compatible with stress, alignment, positioning, and load considerations. When machine screws or bolts are required, the number of turns and the amount of torque should be no more than necessary to provide the required strength except when a common fastener is utilized. All items requiring removal for daily or more frequently scheduled inspections and servicing should use quick release fasteners.

D5.8.9. Attachments. Connected appurtenances, accessories, cables, hoses, and similar items should not interfere with removing, replacing, or carrying an item. If such connected appurtenances interfere with these tasks, they should be easily removed or disconnected from the equipment before handling. Easy disconnect should consist of hand operable quick disconnect or standard hand tool operable disconnects in that order of preference.

D5.8.10. Mounting.

D5.8.10.1. General. Equipment configuration should preclude improper mounting.

D5.8.10.2. Tools. Items maintained at the organizational level should be replaceable using only common hand tools.

D5.8.10.3. Removal. Replaceable items should be removable along a straight or slightly curved line, rather than through an angle.

D5.8.10.4. Limit stops. Limit stops should be provided on drawers. Drawers should be self-locking in the retracted and extended positions. The limit stop design should permit convenient overriding of stops for drawer removal.

D5.8.11. Covers or panels. Removal of any replaceable item should require opening or removing a minimum number of covers or panels.

D5.8.12. Conductors.

D5.8.12.1. Cable clamps. Unless wiring ducts or conduits are used, mechanically (not adhesively) mounted cable clamps should be provided to ensure correct routing of electrical cables within and between equipment items to ensure that cables do not hinder or obstruct equipment maintenance, to facilitate the mating of cables with their associated equipment items, and to prevent chafing due to contact with adjacent structure. All clamps should be visible when equipment is installed.

D5.8.12.2. Cable routing. Cable routing should not obstruct visual or physical access to equipment for storage, operation, or maintenance.

D5.8.12.3. Access. Cables should be routed so as to be accessible for inspection and maintenance.

D5.8.12.4. Susceptibility to abuse. Cables should be routed or protected to preclude

## DFP-420

mechanical damage and abuse, including damage by doors, lids, use as steps or hand holds, or being bent or twisted sharply or repeatedly.

D5.8.12.5. Identification. Cables should be labeled to indicate the equipment to which they belong and the connectors with which they mate.

### D5.8.13. Fuses and circuit breakers.

D5.8.13.1. General. A positive indication should be provided to reveal that a fuse or circuit breaker has opened a circuit.

D5.8.13.2. Replacement and resetting. Fuses should be readily accessible for removal and replacement. No other components should require removal in order to gain access to fuses. No special tools should be required for fuse replacement unless required by safety considerations. When resetting of circuit breakers is permissible, and is required for system operation during a mission, the breakers should be located within reach of the operator when standing at the control panel.

D5.8.13.3. Markings. Equipment served by the fuse or circuit breaker should be labeled. Labeling of fuses and circuit breakers should be legible in the anticipated ambient illumination range for the operator's location.

D5.8.13.4. Circuit breaker controls. Toggle bat and legend switch actuated circuit breakers may be used to control electrical power. Push-pull type breakers should not be used as power switches.

D5.8.14. Drain valves. Drain valves should be readily accessible and hand-operable by the full range of user personnel wearing either Arctic or NBC garments.

D5.8.15. Filters. Fuel and oil filters should be located in accessible positions for inspection and replacement and should not require the removal of other parts.

D5.8.16. Adjustment and access. Components requiring adjustment or replacement, such as fuel injectors and fan belts, should be as accessible as possible.

### D5.9. Labeling

#### D5.9.1. General

D5.9.1.1. Application. Labels, legends, placards, signs, markings, or a combination of these should be provided whenever personnel must identify items (except where it is obvious to the observer what an item is and what he or she is to do with it) or follow procedures.

D5.9.1.2. Label characteristics. Label characteristics should be consistent with required accuracy of identification, time available for recognition or other responses, distance at which the labels must be read, illuminant level and color, criticality of the function labeled, and label design practices used elsewhere on the SATS.

#### D5.9.2. Orientation and location.

D5.9.2.1. Orientation. Labels and information thereon should be oriented horizontally so that



## DFP-420

they may be read from left to right. Vertical orientation may be used only when labels are not critical for personnel safety or performance and where space is limited. When used, vertical labels should read from top to bottom.

D5.9.2.2. Location. Labels should be placed on or very near the items which they identify, so as to eliminate confusion with other items and labels. Labels should be located so as not to obscure any other information needed by the operator.

D5.9.3. Standardization. Labels should be located consistently throughout the system.

D5.9.4. Contents.

D5.9.4.1. Equipment functions. Labels should primarily describe the functions of equipment items. Nomenclature may be described as a secondary consideration.

D5.9.4.2. Irrelevant information. Trade names and other irrelevant information should not appear on labels or placards.

D5.9.5. Qualities.

D5.9.5.1. Brevity. Labels should be unambiguous and as concise as possible without distorting the intended meaning or information. Redundancy should be minimized. Where a general function is obvious, only the specific function should be identified (e.g., “rpm” rather than “engine rpm”).

D5.9.5.2. Familiarity. Words should be familiar to the operator. For specific users (e.g., maintainers), common technical terms may be used even though they may be unfamiliar to nonusers. Abstract symbols (e.g., squares and Greek letters) should be used only when they have an accepted meaning to all intended readers. Common, meaningful symbols (e.g., % and +) may be used.

D5.9.5.3. Visibility and legibility. Labels and placards should be easy to read accurately from the operational reading distances and in the anticipated vibration and illumination environments.

D5.9.5.4. Access. Item labels should not be covered or obscured by other items.

D5.9.5.5. Label life. Labels should be mounted so as to minimize wear or obscurement by grease, grime, or dirt, and should remain legible for the overhaul interval of the labeled equipment.

D5.9.5.6. Contrast and background. Label color should contrast with the equipment background.

D5.9.6. Design of label characters.

D5.9.6.1. Black characters. Where the ambient illuminance will be above 10 lux (0.9 ft-c), black characters should be provided on a light background.

D5.9.6.2. Style. Sans serif block letter fonts having the size ratios specified herein should be used. Examples of acceptable commercial fonts are Futura medium, Futura tempo bold, Futura demibold, Airport semibold, Vogue medium, Lining Gothic No. 66, and Alternate Gothic No. 8.

D5.9.6.3. Capital vs lower case.

## DFP-420

D5.9.6.3.1. Labels. Labels should be printed in all capitals, except where lower case letters or punctuation marks are indigenous to the item being identified.

D5.9.6.3.2. Legends. Legends should be printed in all capitals, without periods or commas.

D5.9.6.3.3. Placards. Instructional placards may use capitals and lower case (sentence case) when the message exceeds two lines; however, for short, instructional material, all-capitals are preferred. All-capital material (consisting of a larger cap for the initial letter in a paragraph, line of instruction, or procedural step) may be used.

D5.9.6.3.4. Signs. Signs should consist of all-capitals, except when the sign is instructional and involves several lines of extended sentences, in which case sentence case may be used.

D5.9.6.4. Letter width. The width of letters should be  $\frac{3}{5}$  of the height, except for “M” and “W”, which should be  $\frac{4}{5}$  of the height, and “I,” which should be one stroke wide.

D5.9.6.5. Numeral width. The width of numerals should preferably be  $\frac{3}{5}$  of the height, except for “4,” which should be one stroke width wider, and “1,” which should be one stroke wide.

D5.9.6.6. Wide characters. Where wide characters are required, e.g., for curved surfaces or for column alignment of numbers, the basic height-to-width ratio may be increased to as much as 1:1.

D5.9.6.7. Stroke width, normal. For black characters on a white (or light) background, the stroke width should be  $\frac{1}{6}$  to  $\frac{1}{7}$  of the height.

D5.9.6.8. Character spacing. The minimum space between characters should be one stroke width.

D5.9.6.9. Word spacing. Space between words should be not less than the width of one character.

D5.9.6.10. Line spacing. The minimum space between lines should be one-half character height.

D5.9.6.11. Size vs luminance. The height of letters and numerals should conform to Table V.

D5.9.6.12. Character height and viewing distance. See Table IX.

## DFP-420

TABLE IX.

### Label size versus luminance

MARKINGS	HEIGHT <sup>1</sup>	
	≤3.5 cd/m <sup>2</sup> (1 ft—L)	>3.5 cd/m <sup>2</sup> (1 ft—L)
Critical markings with position fixed (e.g., safety or emergency instructions)	4—8 mm 0.16 - 0.31 in)	2.5—5 mm (0.10 - 0.20 in)
Noncritical markings (e.g., identification labels, routine instructions, or markings required only for familiarization)	1.3—5 mm (0.05—0.20 in)	1.3—5 mm (0.05—0.20 in)

<sup>1</sup>Values assume a 710 mm (28 in.) viewing distance. For other distances, multiply the above values by D/710 mm (D/28 in.).

#### D5.10. Hazards and safety.

D5.10.1. General. Design should reflect the safety related human engineering criteria below as well as in other sections of this standard.

#### D5.10.2. General workspace hazards.

D5.10.2.1. Obstructions. Areas where operation, storage, or maintenance is performed should be free of obstructions which could cause injury to personnel, either through accidental contact with the obstruction or because the obstruction requires an awkward or dangerous body position.

D5.10.2.2. Handles. Handles on equipment should be recessed whenever practicable, to eliminate projections on the surface. If handles cannot be recessed, they should be configured, located, and oriented to preclude injuring personnel or entangling their clothing or equipment.

D5.10.2.3. Thermal contact hazards. Equipment which, in normal operation, exposes personnel to surface temperatures greater or less than those shown below, should be appropriately guarded. Surface temperatures induced by climatic environment are exempt from this requirement.

## DFP-420

<u>Exposure</u>	<u>Temperature limits</u>		
	<u>Metal</u>	<u>Glass</u>	<u>Plastic or wood</u>
Momentary contact	60° C (140° F)	68° C (154° F)	85° C (185° F)
Prolonged contact or handling	49° C (120° F)	59° C (138° F)	69° C (156° F)
Momentary or prolonged contact or handling	0° C (32° F)	0° C (32° F)	0° C (32° F)

### D5.10.3. General equipment-related hazards.

D5.10.3.1. Access. Equipment items should be so located and mounted that access to them can be achieved without danger to personnel from electrical, thermal, mechanical, or other hazards.

D5.10.3.2. Edge rounding. Where applicable, all exposed edges and corners should be rounded to a radius not less than 0.75 mm (.03 in). Sharp edges and corners that can present a personal safety hazard or cause equipment damage during usage should be suitably protected or rounded to a radius not less than 13 mm (.05 in).

### D5.10.4. Electrical, mechanical, fluid, toxic, and radiation hazards.

#### D5.10.4.1. Electrical hazards.

D5.10.4.1.1. Insulation of tools. Tools and test leads to be used on or near energized electrical components should be adequately insulated.

D5.10.4.1.2. Plugs and receptacles. Plugs and receptacle configurations should preclude inserting a plug of one voltage rating into a receptacle of another rating.

D5.10.4.1.3. Voltage exposure. All hot contacts should be socket contacts.

D5.10.4.1.4. Dangerous voltage or current. Guards, grounding, interlocks, and warning placards should be provided to minimize exposing personnel to dangerous voltages or currents.

D5.10.4.1.5. Ground potential. Equipment should be designed so that all external parts will be at ground potential.

D5.10.4.1.6. Electrically-operated hand tools. Electrically operated hand-held power tools should be designed with three-wire power cords with one wire at ground potential and should have exposed surfaces which are either non-conducting or are electrically connected to the ground wire. Exposed surfaces include cases, grips, handles, switches, triggers, chucks, and other surfaces which are capable of being contacted during operation. Portable tools which are protected by an approved

## DFP-420

system of double insulation or its equivalent may be used without a ground wire when approved by the procuring activity.

D5.10.4.1.7. Batteries. Batteries that have ratings greater than 25 amp hours should have terminal guarding to prevent inadvertent short-circuit. Such guarding should also prevent short-circuiting the battery in spite of clearly improper but possible acts by personnel, such as placing tools across terminals.

D5.10.4.2. Mechanical hazards. A guard should be provided on all moving parts of machinery and power transmission equipment, including pulleys, belts, gears, and blades, on which personnel may become injured or entangled.

D5.10.4.3. Toxic hazards. Personnel should not be exposed to the concentrations of toxic substances in excess of the limits specified in Occupational Safety and Health (OSH) standards.

### D5.10.5. Stairs, stair-ladders, fixed ladders, and ramps.

#### D5.10.5.1. General criteria.

D5.10.5.1.1. Selection. The selection of stairs, stair-ladders, fixed ladders, or ramps for specific applications shall be based on the angle of ascent required and the criteria in Figure 7.

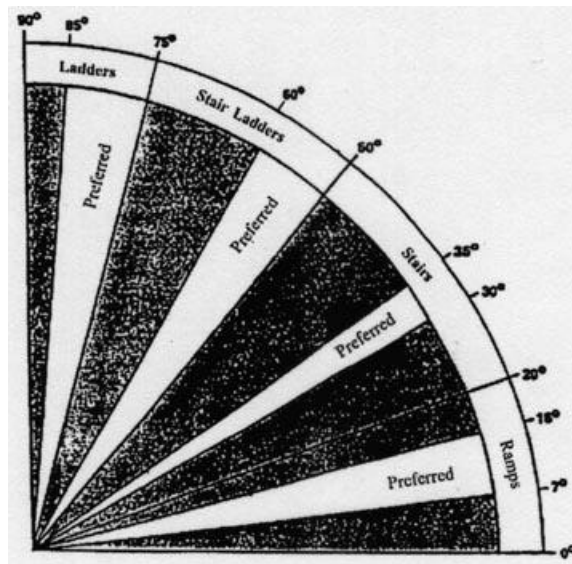


Figure 7. Selection Criteria for Ladders, Stair-Ladders, Stairs, and Ramps

D5.10.5.1.2. Provision for hand-carrying equipment. Ladders and stair-ladders shall not be used where hand-carrying of equipment is required, since both hands should be free to grasp the ladder. Stairs should not be used where hand-carrying bulky loads or loads in excess of 13 kg (29 lbs) is required (see Table I). Ramps, elevators, or equivalent means should be provided when heavy

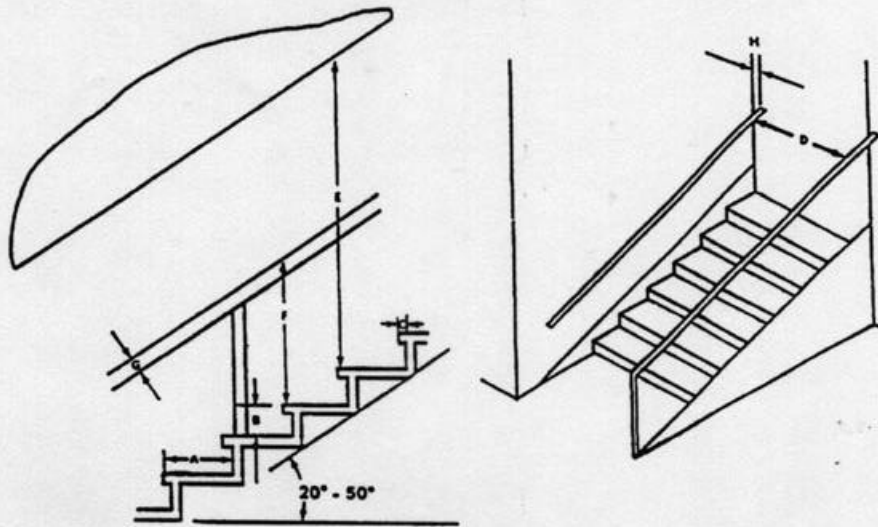
## **DFP-420**

equipment must be manually transported.

D5.10.5.1.3. Handrails and guardrails. Stairs, stair-ladders, fixed ladders, and ramps should be equipped with a handrail on each side. Where one or both sides are open, appropriate intermediate guardrails shall be provided to prevent personnel injury. Non-fixed vehicular-boarding ladders are neither stair ladders nor fixed ladders and are exempt from this requirement.

D5.10.5.2. Stairs. Stair dimensions should conform to the recommended values and shall be within the minimum and maximum limits of Table X.

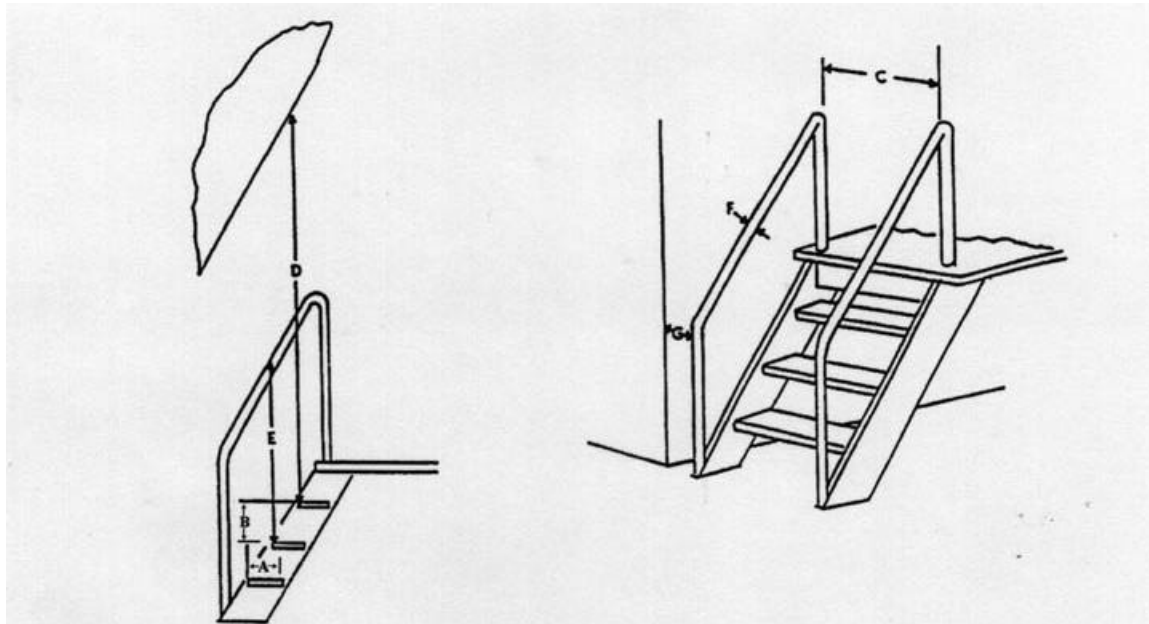
# DFP-420



DIMENSION	MINIMUM	MAXIMUM	RECOMMENDED
A Tread depth (including nosing)	240mm (9.5 in.)	300 mm (12 in.)	280-300 mm (11-12 in.)
B Riser height	125 mm (5 in.)	200 mm (8 in.)	165-180 mm (6.5-7 in.)
C Depth of nosing (where applicable)	19 mm (0.75 in.)	38 mm (1.5 in.)	25 mm (1 in.)
D Width (handrail to handrail):			
One-way stairs	760 mm (30 in.)	---	910 mm (36 in.)
Two-way stairs	1220 mm (48 in.)	---	1300 mm (51 in.)
E Overhead clearance	1930 mm (76 in.)	---	1980 mm (78 in.)
F Height of handrail (from leading edge of tread)	840 mm (33 in.)	940 mm (37 in.)	840 mm (33 in.)
G Handrail diameter	32 mm (1.125 in.)	75 mm (3 in.)	38 mm (1.5 in.)
H Rail clearance from wall	45 mm (1.75 in.)	---	75 mm (3 in.)

Table X. Stair Dimensions

D5.10.5.3. Stair ladders. Stair ladder dimensions should conform to the recommended values and shall be within the specified minimum and maximum limits of Table XI. The tread rise shall be open at the rear. Landings should be provided every tenth or twelfth tread. The surface of treads on exterior stair ladders should be constructed of open grating material or should be treated with nonskid material.



DIMENSION	MINIMUM	MAXIMUM	RECOMMENDED
A Tread depth range:			
For 50° rise	150 mm (6 in.)	250 mm (10 in.)	215 mm (8.5 in.)
For 75° rise (open ladders only)	75 mm (3 in.)	140 mm (5.5 in.)	100 mm (4 in.)
B Riser height	180 mm (7 in.)	300 mm (12 in.)	230 mm (9 in.)
C Width (handrail to handrail)	530 mm (21 in.)	610 mm (24 in.)	560 mm (22 in.)
D Overhead clearance	1730 mm* (68 in.)	---	1930 mm (78 in.)
E Height of handrail (from leading edge of tread)	860 mm (34 in.)	940 mm (37 in.)	890 mm (35 in.)
F Handrail diameter	32 mm (1.125 in.)	75 mm (3 in.)	38 mm (1.5 in.)
G Rail clearance from wall	50 mm (2 in.)	---	75 mm (3 in.)

\* Whenever the distance D is less than 1,880 mm (74 in.), the overhead obstruction should be painted with yellow and black stripes.

Table XI. Stair-Ladders

#### D5.11. Trailers, vans, and intervehicular connections.

##### D5.11.1. Trailers.

D5.11.1.1. Brake controls. Trailer brake controls shall be located so that an operator can reach them while restraining or positioning the trailer manually. The controls shall not be located on the side of the trailer exposed to road traffic.



## DFP-420

D5.11.1.2. Positioning controls. Component trailers should contain precise positioning controls when the trailer will be used to mate parts.

D5.11.1.3. Tie-downs. Munitions tie-down facilities on stores trailers shall be easily installed and removed.

D5.11.1.4. Landing gear lock. Landing gear lock and release shall be capable of being hand or foot-operated.

D5.11.2. Vans. The following criteria applies to trailer vans and transportable shelters which serve as shelters for personnel or equipment, and which require occupancy by personnel for operational or maintenance tasks in excess of one hour, on a recurring basis where mission requirements permit:

D5.11.2.1. Ceiling height. The ceiling height (distance from the floor to the bottom of any light, cable run, or other protuberance over the aisle or standing work-space) shall be not less than 198 cm (78 in) for vans and shelters, except as follows: When the occupants seldom stand to perform normal operations, the ceiling height can be reduced to 189 cm (74.5 in) unless otherwise specified by the procuring activity.

D5.11.2.2. Access openings. Personnel access openings shall be not less than 193 cm (76 in) high and 76 cm (30 in) wide. Equipment access opening shall accommodate the specific equipment to be transported, including suitable clearances for handling. Access doors shall have provisions for being locked in open positions as well as closed positions. All access doors shall have inner quick-opening releases.

D5.11.2.3. Steps, stairs, ladders. Steps, stairs, or ladders shall be provided when van floors are more than 46 cm (18 in) above ground level.

D5.11.2.4. Inclinometers. On work spaces such as large personnel-occupied vans or shelters, intended for use as mobile work spaces, inclinometers shall be provided to permit readout of front-rear and side-side tilt within  $\pm 2^\circ$ .

D5.12. General. Design shall reflect the safety related human engineering criteria below as well as in other sections of this standard.

### D5.12.1. Safety labels and placards.

D5.12.1.1. Warning placards. Conspicuous placards shall be mounted adjacent to any equipment which presents a hazard to personnel (e.g., from high voltage, heat, toxic vapors, explosion, radiation). Warning placards shall be located to provide an advanced alert of the potential health hazards while not placing the reader at risk to exposure.

D5.12.1.2. Center-of-gravity and weight. Where applicable, the center of gravity and the weight of equipment shall be distinctly marked.

## **DFP-420**

D5.12.1.3. Weight capacity. The weight capacity shall be indicated on stands, hoists, lifts, jacks, and similar weight-bearing equipment, so as to prevent overloading.

D5.12.1.4. Identification of protective items. Areas of operation or maintenance where special protective clothing, tools, or equipment are necessary (e.g., insulated shoes, gloves, suits) shall be specifically identified.

D5.12.1.5. "NO-STEP" markings. "NO-STEP" markings shall be provided when necessary to prevent injury to personnel or damage to equipment.

D5.12.1.6. Electrical labels. All receptacles shall be marked with their voltage, phase, and frequency characteristics, as appropriate. For other electrical labeling and warning requirements, see MIL-HDBK-454.

D5.12.1.7. Hand grasp areas. Hand grasp areas shall be conspicuously and unambiguously identified on the equipment.

D5.12.1.8. Pipe, hose and tube line identification. Pipe, hose, and tube lines for liquids, gas, steam, and etc., shall be clearly and unambiguously labeled or coded as to contents, pressure, heat, cold, or other specific hazardous properties.

### D5.12.2. General workspace hazards.

D5.12.2.1. Alerting device. A hazard alerting device shall be provided to warn personnel of impending danger or existing hazards (e.g., fire, the presence of combustible or asphyxiating gas, and radiation.).

D5.12.2.2. Emergency doors and exits. Emergency doors and exits shall be readily accessible, unobstructed, simple to operate, simple to locate in the dark, quick opening in three seconds or less, and require 44 - 133 N (10 - 30 lb) of operating force to open. They shall not themselves, or in operation, constitute a safety hazard. They shall permit one person egress in 5 seconds or less.

D5.12.2.3. Stairs. Stairs, including incline, step risers, and treads, shall conform with standard safe design practice. Skid-proof flooring, stair, and step treads shall be provided. Where conditions warrant special precaution, surfaces shall be treated with a nonslip coating.

D5.12.2.4. Obstructions. Workspace around areas where maintenance is performed shall be free of obstructions which could cause injury to personnel, either through accidental contact with the obstruction or because the obstruction requires an awkward or dangerous body position.

D5.12.2.5. Illumination. Adequate illumination shall be provided in all areas. Warning placards,

## DFP-420

stairways, and all hazardous areas shall be illuminated in accordance with the recommended levels of Table XXI.

### D5.12.3. Electrical hazards.

D5.12.3.1. Insulation of tools. Tools and test leads to be used near high voltages shall be adequately insulated.

D5.12.3.2. Plugs and receptacles. Plugs and receptacle configurations shall preclude inserting a plug of one voltage rating into a receptacle of another rating.

D5.12.3.3. Voltage exposure. All hot contacts shall be socket contacts.

D5.12.3.4. Dangerous voltage or current. Guards, grounding, interlocks, and warning placards shall be provided to minimize exposing personnel to dangerous voltages or currents.

D5.12.3.5. Ground potential. Equipment shall be designed so that all external parts, other than antenna and transmission line terminals, will be at ground potential.

D5.12.3.6. Electrically-operated hand tools. Electrically operated hand-held power tools shall be designed with three-wire power cords with one wire at ground potential and shall have exposed surfaces which are either non-conducting or are electrically connected to the ground wire. Exposed surfaces include cases, grips, handles, switches, triggers, chucks, and other surfaces which are capable of being contacted during operation. Portable tools, protected by an approved system of double insulation or its equivalent, may be used without a ground wire when approved by the procuring activity.

**DFP-420**

APPENDIX E

PERFORMANCE REQUIREMENTS FOR  
FOR  
TRAILER-MOUNTED SETS, KITS, AND OUTFITS

## DFP-420

### E1. SCOPE

E1.1. Scope. This appendix establishes specific mobility criteria for Sets, Kits and Outfits (SKOs) mounted on Army tactical trailers. This appendix is a mandatory part of this specification. The information contained herein is intended for compliance.

E1.2. Purpose. These requirements are predicated upon the SKO being assembled to a non-standard tactical trailer.

### E2. APPLICABLE DOCUMENTS

The documents cited in this section are for reference only, and do not constitute a part of this standard. They are provided as a source of additional information.

#### E2.1. Government documents.

### SPECIFICATIONS

#### DEPARTMENT OF DEFENSE

MIL-DTL-45150 - Chassis, Trailer, 2-Wheel Cart Type ¼ to 3-1/2 Ton

### STANDARDS

#### DEPARTMENT OF DEFENSE

MIL-STD-810 - Environmental Test Methods and Engineering Guidelines

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Standardization Documents Order desk, 700 Robbins Avenue, Bldg 4D, Philadelphia, PA 19111-5094.)

#### E2.2. Non-Government publications.

### SOCIETY OF AUTOMOTIVE ENGINEERS

AS8090 - Mobility, Towed Aerospace Ground Equipment, General Requirements for

## DFP-420

(Application for copies should be addressed to the Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096-0001).

### E3. PERFORMANCE

The trailer-mounted SKO shall perform as follows when being towed by its preferred prime mover.

E3.1. Speed. The trailer-mounted SKO shall trail safely behind its preferred prime mover at all speeds up to and including the maximum recommended for the combination of prime mover, trailer chassis, and towing surface.

#### E3.2. Tracking.

E3.2.1. Straightaways. When following a straight course, the longitudinal centerline of the trailer-mounted SKO shall remain aligned with the longitudinal centerline of the prime mover. The trailer shall not exhibit excessive crab, yaw, or sway such that the path of the trailer deviates more than three inches to either side of the path of the towing vehicle.

E3.2.2. Turns. On dry, level pavement, the trailer-mounted SKO shall safely trail through turns when the steering mechanism of the prime mover is at its maximum cramping angle. Turns shall be taken at 10 miles per hour or the maximum safe turning speed for the prime mover under the test conditions, whichever is less. When turning, the wheels of the trailer shall follow an arc concentric to that traversed by the wheels of the prime mover. The trailer shall not skid, and shall not tilt or turn over. There shall be no interference between any part of the trailer-mounted SKO and its preferred prime mover at any turning radius the prime mover can execute.

E3.3. Loading ramps. When entering or leaving longitudinal slopes of up to 35% grade (20 degrees from the horizontal) such as a loading ramp, there shall neither be interference between the trailer-mounted SKO and its preferred prime mover nor interference between the trailer-mounted SKO and the towing surface. Traversing the slope shall not damage the SKO, nor shall any component be displaced.

E3.4. Side slopes. When traversing side slopes the centerline of the trailer-mounted SKO shall remain aligned with the centerline of the prime mover and the trailer shall not tilt or turn over.

E3.5. Braking. The trailer-mounted SKO shall withstand sudden stops from initial speeds up to the maximum safe speed for the prime mover without damage and without displacement of any component. When braking, the trailer shall not jackknife and shall not exhibit wheel hop.

### E4. TESTS

E4.1. Speed and tracking. The fully-loaded trailer-mounted SKO shall be towed by its preferred prime mover. While being towed, the trailer-mounted SKO shall be observed to determine whether the trailer crabs, yaws, or sways. If there is any doubt regarding the extent of deviation between the path of the trailer and the path of the towing vehicle, a visible trail shall be produced by pouring water on the tires (or by other suitable means) and the deviation measured. These observations

## DFP-420

shall be taken in conjunction with roadability and mobility testing of the SKO.

E4.2. Turning. The trailer-mounted SKO shall be hitched to its preferred prime mover and towed in a “figure 8” over smooth, dry pavement. The radius of each turn shall be made progressively smaller, until the prime mover’s maximum cramping angle is reached. The prime mover shall maintain a speed of at least ten miles per hour, or it’s maximum safe speed for that turning raduis, whichever is less. While turning, the trailer-mounted SKO shall be observed to determine whether the trailer skids, tilts, or turns over. If there is any doubt regarding the concentricity between the path of the trailer and the path of the towing vehicle, a visible trail shall be produced by pouring water on the tires (or by other suitable means) and the tracks examined.

E4.3. Loading ramp. The trailer-mounted SKO shall be towed by its preferred prime mover both up and down a ramp inclined at least 20 degrees to the horizontal. The bottom and top of the ramp shall end in horizontal landings that form a sharply defined angle with the ramp. The length of the ramp, measured along the slope, shall be not less than 1.2 times the wheelbase of the vehicle/trailer combination. The Simulated Loading Ramp at Aberdeen Proving Ground (APG) is one example of a suitable facility for the test (See Figure E1).

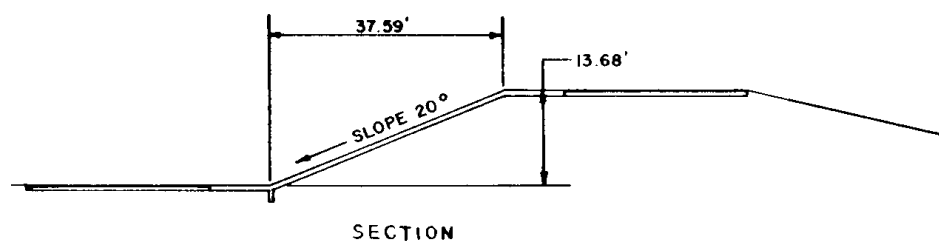


Figure E1. Example of Simulated Loading Ramp

E4.4. Sudden stops. The fully loaded trailer-mounted SKO shall be towed by its preferred prime mover over a clean, dry, smooth, level, high-speed paved road at a speed of at least 20 mph. The brakes shall be suddenly and fully applied (maximum pedal effort braking) to bring the prime mover and trailer to a complete emergency stop. The procedure shall be repeated at successively higher speeds until the maxim safe braking speed is achieved. Road speed shall be increased in increments of 5 mph between stops. The criterion for maximum safe speed at maximum pedal effort is that vehicle slew shall not exceed the limits of a roadway lane width equal to 1.5 times the width of the prime mover. The test shall be repeated with the removable components of the SKO removed from the trailer. During each stop the trailer-mounted SKO shall be observed to determine if axle hop is evident, and whether the trailer jackknifes. Following each stop, the trailer-mounted SKO shall be examined for visible structural damage and for damage to or displacement of any stowed component.

## E5. DEFINITIONS

E5.1. Crab. To move sideways or diagonally (dogwalk). In the specific case of a trailer, to follow a straight course with its longitudinal centerline at an angle to that of the prime mover.

## DFP-420

E5.2. Slew. To turn, twist, move, or skid to the side.

E5.3. Sway. To move back and forth with a swinging motion. In the specific case of a trailer, to move from side to side about the pintle.

E5.4. Skid. To slide or slip sideways. In the specific case of a trailer, to lose traction during a turn so that the trailer slips sideways on its tires in response to centrifugal force.

E5.5. Tilt. To incline, as by raising one end. In the specific case of a trailer, to lean over in response to centrifugal force during a turn to the extent that one or more wheels loses contact with the surface being traversed.

E5.6. Jackknife. To fold or double like a jackknife. In the specific case of a trailer, to swing around the pintle to one side or the other during braking.

E5.7. Hop. To move with light bounding skips or leaps. In the specific case of a trailer, to develop a vertical oscillation such that one or more wheels intermittently loses contact with the surface being traversed.

E5.8. Preferred prime mover. Each model of Army standard tactical trailer has been designed and tested for acceptable performance when towed by a specific model or family of Army standard tactical truck. The preferred prime movers for Army standard 2 – wheel tactical trailers are specified in MIL-DTL-45150.

## E6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

E6.1. The performance requirements in this appendix were extracted and adapted in part from SAE AS8090, “Mobility, Towed Aerospace Ground Equipment, General requirements for,” (formerly MIL-M-8090). The requirements extracted from SAE AS8090 were those addressing mobility Type V, “Mobile on highways and unimproved cross-country terrain.” Performance requirements were also extracted as applicable from MIL-DTL-45150, “Chassis, Trailer, 2-Wheel Cart Type ¼ to 3-1/2 Ton.”



**DFP-420**

APPENDIX F

PERFORMANCE REQUIREMENTS FOR  
SHELTER, TACTICAL, NON-EXPANDABLE, WITH PROVISIONS FOR INTEGRAL  
ENVIRONMENTAL CONTROL UNIT AND GENERATOR SET

## DFP-420

### F1. SCOPE.

F1.1 Scope. This appendix established specific requirements for a nonexpendable, rigid wall, relocatable shelter meeting the dimensional and stacking strength requirements of International Organization for Standardization (ISO) Type 1C Cargo Containers for purposes of transport. Nominal dimensions are: height 8 ft, width 8 ft, and length 20 ft (2.4 by 2.4 by 6.1 m). It is a variant of the Army Standard "Shelter, Tactical, Non-Expandable, 100 Amp." In addition to the general cargo area, the shelter is provided with integral compartment(s) and wiring for a 10 KW electrical generator and an Environmental Control Unit (ECU). This appendix is a mandatory part of this specification. The information contained herein is intended for compliance, predicated on the SKO being incorporated in a non-standard tactical shelter.

F1.2 Measurement system. The values stated in inch-pound units are to be regarded as the standard. The SI units given in parentheses are for information only. (Reference ASTM SI 10)

### F2. APPLICABLE DOCUMENTS

F2.1 General. The documents listed in this section are specified in sections 3 and 4 of this specification appendix. This section does not include documents recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements documents cited in sections 3 and 4 of this appendix, whether or not they are listed.

#### F2.2 Government documents.

F2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation (see paragraph 6.2).

## SPECIFICATIONS

### FEDERAL

A-A-1927	- Padlock
A-A-50271	- Plate, Identification
A-A-55804	- Rods, Ground (with attachments)
A-A-59559	- Post, Binding, Electrical, Waterproof (Insulated), Dual

## **DFP-420**

### O-ring Seal

#### MILITARY

MIL-C-22992	- Connectors, Plugs, and Receptacles, Electrical, Waterproof, Quick disconnect, Heavy Duty Type, General specification for
MIL-T-27260	- Tie Down, Cargo, Aircraft, CGU-1/B
MIL-P-27443	- Pallets, Cargo, Aircraft, Type HCU-6/E, HCU-12/E, and HCU-10/C
MS14055	- Insert Arrangements, Electrical Connector, Size 44, Class L, 60 Amps
MS90558	- Connector, Receptacle, Electrical, Wall Mounting (with Coupling Ring) Class L (Equipment Receptacle)
MS90564	- Cover, Electrical Connector, Plug, Class L

#### STANDARDS

##### FEDERAL

FED-STD-595	- Colors Used in Government Procurement
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##### DEPARTMENT OF DEFENSE

MIL-STD-129	- Standard Practice for Military Marking
MIL-STD-171	- Finishing of Wood and Metal Surfaces
MIL-STD-209	- Interface Standard for Lifting and Tie-down Provisions
MIL-STD-810	- Environmental Test Methods and Engineering Guidelines
MIL-STD-913	- Requirements for the Certification of Sling Loaded Military Equipment for External Transportation by Department of Defense Helicopters

## **DFP-420**

MIL-STD-1472

- Department of Defense Design Criteria Standard, Human Engineering

## **HANDBOOKS**

MIL-HDBK-784

- Guidelines – Design to Minimize Contamination and to Facilitate Decontamination of Military Vehicles and Other Equipment: Interiors and Exteriors

MIL-HDBK-1791

- Designing for Internal Aerial Delivery in Fixed Wing Aircraft

(Unless otherwise indicated, copies of the above specifications, standards, and handbooks are available from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094).

F2.2.2 Other Government documents, drawings and publications. The following other Government documents, drawings, and publications form a part of this document to extent specified herein. Unless otherwise specified, the issues are those cited in the solicitation.

## **DRAWINGS**

5-4-6865

- Shelter, Assembly, Non-Expandable-100 Amp

## **TECHNICAL MANUALS**

TM 9-4120-425-14&P

- Operator's, Unit, Direct Support and General Support Maintenance Manual Including Repair Parts and Special Tools List for Air Conditioner, Horizontal, Compact, 36,000 BTU/Hr, 208 Volt, Three Phase, 50/50 Hz, Part No. S9500-36KH-1, NSN 4120-01-467-2638

TM 9-6115-642-10

- Operator's Manual, Generator Set, Skid Mounted, Tactical Quiet, 10 KW, 60 and 400 Hz, MEP-803A (60 Hz) 6115-01-275-5061, MEP-813A (400 Hz) 6115-01-274-7392

TM 10-5411-202-24P

- Organizational, Direct Support and General Support Maintenance Repair Parts and Special Tools List for

## **DFP-420**

### **Shelter, Tactical, Non-Expandable**

Copies of drawings and Technical Manuals are available from the U.S. Army Natick Research, Development, and Engineering Center, Attn: SSCNC-WST, Natick, MA 07160-5018.

F2.3 Non-Government publications. The following document(s) form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents that are DoD adopted are those listed in the issue of the DoDISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DoDISS are the issues of the documents cited in the solicitation (see paragraph 6.2)

#### **AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)**

ANSI Z535.4                      - Product Safety Signs and Labels

(Application for copies should be addressed to the American National Standards Institute, 11 W. 42<sup>nd</sup> Street, New York, New York 10036.)

#### **ASSOCIATION OF AMERICAN RAILROADS**

Rules Governing the Loading of Department of Defense Materiel on Open Top Cars

(Application for copies should be addressed to the Publications Department, Association of American Railroads, Transportation Technology Center, Inc., PO Box 79780, Baltimore MD 21279-0780, 877-999-8824 (toll free), email: pubs@aar.com).

#### **AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)**

ASTM E 1925                      - Specification for Engineering and Design Criteria for Rigid Wall Relocatable Structures

ASTM E 1976                      - Specification for Shelter, Tactical, Nonexpandable

ASTM SI 10                        - Standard for Use of the International System of Units (SI): The Modern Metric System

(Application for copies should be addressed to the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, Pa 19428-2959.)

## DFP-420

### INTERNATIONAL STANDARDS ORGANIZATION (ISO)

ISO 668	- Series 1 freight containers – Classification, dimensions and ratings
ISO 830	- Freight Containers - Vocabulary
ISO 1161	- Series 1 freight containers - Corner Fittings - Specification
ISO 1496-1	- Series 1 freight containers - Specification and testing - Part I: General cargo containers for general purposes

(Application for copies should be addressed to the American National Standards Institute, 11 W. 42<sup>nd</sup> Street, New York, New York 10036.)

### NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION

NEMA WD 6	- Wiring Devices – Dimensional Specifications
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(Application for copies should be addressed to the National electrical Manufacturers Association, 1300 North 17<sup>th</sup> Street, Rosslyn, VA 22209.)

F2.4 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

## F3. REQUIREMENTS

F3.1 First article. When specified, a sample shall be subjected to first article inspection in accordance with paragraph 4.2.1.

F3.2 Definitions. Terminology related to freight containers used in this specification is defined in ISO 830.

F3.3 Design. The shelter shall be designed and built to withstand a variety of environments while providing an effective and reliable facility for storage, transport, and operation of installed equipment, as well as a suitable working environment for troops deployed for military operations in the field.

F3.3.1 Standardization. The requirements specified herein are intended to promote standardization of rigid wall relocatable shelters. Existing commercial and (where necessary) military performance and test criteria have been used to the maximum extent possible. A Technical Data Package consisting of Army

## DFP-420

Drawing 5-4-6865 and its subordinate drawings and specifications is cited for reference. Subject to the performance requirements specified herein, the shelter design shall incorporate to the maximum extent practicable shelter parts already established in the Army supply system. Such parts are listed in TM 10-5411-202-24P with National Stock Numbers (NSNs).

F3.3.2 Simplicity. The contractor shall provide the simplest design consistent with performance requirements. The design shall also be directed toward minimizing the physical exertion, man-hours, tools, and other equipment required to prepare the shelter for operation and for transport.

F3.3.3 Weight. To provide the greatest mobility for military forces, the contractor shall construct the shelter of materials with high strength-to-weight ratios. The current Army TDP for non-expandable shelters requires the use of aluminum alloy frame members and panels fabricated of aluminum alloy skins that are bonded to a non-metallic honeycomb core and sealed to a welded frame of square aluminum alloy tubing. The contractor shall provide shelters constructed of materials that meet the requirements of this document and provide performance equal to or better than the materials of the current design with equal or less weight per unit volume.

F3.4 Performance. The shelter shall meet all requirements specified herein. As a special-purpose tactical shelter, the specifications are an amalgam of requirements and modified requirements from referenced ASTM, ANSI, ISO, and Military Standards. Where feasible, these requirements have been incorporated in the text of this specification either verbatim, or with modifications consistent with the intended use of the item.

F3.4.1 Physical security. The shelter shall be lockable and provide physical security for all internally stored or mounted equipment and supplies sufficient to discourage tampering, unauthorized use, and theft.

F3.4.1.1 Locks. Locking of the shelter shall be accomplished with padlocks. The hasps and staples or other locking devices incorporated in the shelter shall accept key-operated, tumbler-type padlocks conforming to CID A-A-1927, Type I, Size B, which have shackles with a diameter of  $0.343 \pm 0.040$  inch.

F3.4.1.2 Anti-tampering measures. When the shelter is prepared for transport and storage, the padlock(s) shall be plainly visible on the shelter exterior. It shall not be possible to use or remove any of the components stored in the shelter without either removing the locks or visibly damaging the shelter.

F3.4.1.3 Loss and damage prevention. All doors, panels, and other covers for openings in the shelter shall be permanently affixed to the shelter.

F3.4.1.3.1 Door static load. Vertically hinged doors shall be capable of supporting a 200 lb (90 kg) downward load on the edge opposite the hinge without sustaining damage. (Reference ASTM E 1925)

F3.4.1.3.2 Wind gust load. All doors, panels, and other covers for openings in the shelter shall be provided with latches, stays, or other mechanisms that hold them in the open position and prevent them from damage when subjected to wind gusts up to 60 mph (100 km/h). (Reference ASTM E 1925)

F3.4.2 Electrical outlets. Branch circuits and power outlets for electrical equipment shall be provided

## DFP-420

both inside and outside the shelter. In addition to circuits for the ECU, the interior lights, and the exterior lights, the shelter shall be provided with at least three 125 volt, 20 Ampere circuits for electrical receptacles. The two interior circuits shall have at least four duplex 5-15R receptacles as defined by NEMA WD 6 placed at regular intervals at least five feet above the shelter floor, one circuit for each side of the shelter. The third circuit shall provide at least two 5-15R receptacles with weather-tight covers on each end (front and rear) of the shelter exterior.

F3.4.3 Lighting. The shelter shall provide permanently mounted 110 volt AC interior lighting. The lighting system shall provide switch-selectable white light and Night Vision Device (NVD) safe light (i.e. blue-green light not detectable to NVDs). Two removable 60-Watt white light fixtures shall be provided for the shelter exterior. A mount for one light fixture shall be located near the personnel door, and a mount for the other shall be provided near the generator. The exterior lights shall obtain power from the receptacles located at each end of the shelter exterior.

F3.4.4 Erecting and striking. Erecting and striking the shelter shall be accomplished within two man-hours. The shelter shall be provided with screw jacks or other leveling devices that enable the shelter to sit level on surfaces having up to a 24 in. (610 mm) differential in grade to the diagonal dimension of the shelter floor. (Reference ASTM E 1925)

F3.4.5 Workmanship.

F3.4.5.1 Panel Flatness. Panel surfaces shall not be cupped or bowed in excess of 0.125 in (3 mm) over any 48 in (1300 mm) distance. (Reference ASTM E 1925)

F3.4.5.2 Panel bonding. If the shelter floor, roof, wall, or end panels are of laminated construction, they shall be free of delaminations. (Reference ASTM E 1925)

F3.4.6 Transportability. The fully-loaded shelter shall be suitable for commercial and military shipment via aircraft, ship, railcar, and truck. When configured for transport the shelters shall meet the requirements for ISO freight containers as specified herein. The shelter in the freight container mode shall hereinafter be referred to as a container.

F3.4.6.1 Safety certification. The contractor shall ensure that all containers presented for acceptance by the Government have been certified safe by the Coast Guard or other authorized Approval Authority as required by Code of Federal Regulations (CFR) 49, Parts 450 through 453, and shall provide a copy of the certification paperwork. (Reference ASTM E 1976)

F3.4.6.2 Overall dimensions. The overall exterior dimensions of the containers shall conform to those of ISO 668 general-purpose freight containers designated 1C, as shown in Table F1, or 1CX, which may be less than 8 feet tall. No part of the container, including padlocks, shall extend beyond the planes defined by the outer surfaces of the corner fittings. (Reference ASTM E 1925)

F3.4.6.3 Tare mass. The mass (weight) of the empty container as delivered shall not exceed 4,500 pounds.

F3.4.6.4 Gross mass rating. The container shall be designed for a maximum combined mass (weight) of container and cargo of at least 15,000 lbs. (Reference ASTM E 1976)



## DFP-420

F3.4.6.5 Corner fittings. The containers shall be equipped with corner fittings in accordance with the dimensional requirements for corner fittings for as stipulated in ISO 1161 (See Figures F-6 through F-9). Dimensions and tolerances between corner fittings shall be in accordance with ISO 668 (See Figure F-10). The upper faces of the top corner fittings shall protrude above the top of the rest of the container by minimum of ¼” (6 mm). The lower faces of the bottom corner fittings shall protrude below the bottom of the container by a minimum of 7/16” (11 mm). (Reference ISO 1496-1)

Type	Height		Width		Length	
	ft. in.	Tol. in.	ft. in.	Tol. in.	ft. in.	Tol. in.
1C	8 0	+0 -0.1875	8 0	+0 -0.1875	19 10.5	+0 -0.25
	(2438 mm)	(+0 -5 mm)	(2438 mm)	(+0 -5 mm)	(6058 mm)	(+0 -6 mm)

Table F1. Container Overall Dimensions

F3.4.7 Air transport. The shelter shall be suitable for transport by the U.S. Air Force C130 and larger cargo aircraft and for external airlift by helicopter.

### F3.4.7.1 Cargo aircraft.

F3.4.7.1.1 Decompression vent. The containers shall be capable of withstanding an internal pressure differential of 8.3 psi (0.57bar) developed within 0.5 sec or less without any part of the container becoming a missile. For this purpose, the container shall be provided with a minimum total vent area of 24 in<sup>2</sup> (154.8 cm<sup>2</sup>). Each vent shall be adequately protected from cargo load shift to ensure that the required vent area is available during rapid decompression of an aircraft. (Reference ASTM E 1925)

F3.4.7.1.2 Flight maneuver forces. The containers shall be capable of being restrained against and withstanding forces imposed by aircraft flight and maneuvering operations. For aircraft transport, the containers will each be placed on three HCU-6/E pallets (See MIL-P-27443 for description) connected end-to-end by 2-inch-wide couplers. When latched to the 463L cargo system rails in military aircraft, the pallets are rated under the criteria of MIL-HDBK-1791 to restrain cargo loads of up to 10,000 lbs each, for a total rated load of 30,000 lbs. The perimeter of the combined pallets will provide 42 cargo tie-down rings, each rated at 7,500 lbs in any direction. The contractor shall provide a recommended tie-down pattern for fastening the containers to the pallet tie-down rings with CGU-1/B tie down devices (See MIL-T-27260 for description), which have a rated capacity of 5,000 lbs each. When attached to the pallets using the contractor’s recommended tie-down pattern, the containers, loaded to their rated gross weight with all cargo tied down to the container floor and the generator and ECU installed, shall remain on the pallets, and shall have the mechanical strength to meet the following criteria (Reference MIL-HDBK-1791):

a. Containers shall be capable of withstanding, without loss of serviceability, static forces equal to the dynamic forces imparted by the following accelerations, applied independently (1.0 G is the acceleration

## DFP-420

due to gravity; all directions are relative to the aircraft.):

<u>Direction</u>	<u>Load Factor</u>	<u>Equivalent Static Load</u>
Up	2.0 G	30,000 lbs
Down	4.5 G	67,500 lbs

b. Containers shall be capable withstanding, without loss of structural integrity, static forces equal to the dynamic forces imparted by the following accelerations, applied independently:

<u>Direction</u>	<u>Load Factor</u>	<u>Equivalent Static Load</u>
Forward	3.0 G	45,000 lbs.
Aft	3.0 G	45,000 lbs
Lateral	1.5 G	22,500 lbs

c. The equipment shall also be able to withstand the following independently applied changes in velocity ( $\Delta V$ ) of the aircraft floor within 0.1 second without loss of serviceability. (The final velocity must be held long enough for an adequate cargo response to the input.)

<u>Direction</u>	<u><math>\Delta V</math></u>
Up	10.0 ft/sec
Down	11.5 ft/sec

d. Containers shall be capable of withstanding the following the following independently applied changes in velocity ( $\Delta V$ ) of the aircraft floor within 0.1 sec without loss of structural integrity. (The final velocity must be held long enough for an adequate cargo response to the input.)

<u>Direction</u>	<u><math>\Delta V</math></u>
Forward	10.0 ft/sec
Aft	5.0 ft/sec
Lateral	5.0 ft/sec

F3.4.7.2 Transport provision identification. The container lifting provisions, tie down provisions, and center of gravity shall be identified and labeled in accordance with MIL-STD-129.

F3.4.7.3 Helicopter external lift. The fully loaded container, with generator and ECU installed, shall be certified suitable for External Air Transport (EAT) (sling load) by CH-47 and larger cargo helicopters in accordance with MIL-STD-913.

F3.4.8 Marine transport.

F3.4.8.1 Base strength. When loaded to their gross weight rating and subjected to dynamic vertical accelerations of up to 1.8 G, the containers shall be capable of being supported by their bottom corner

## DFP-420

fittings only, without suffering permanent deformation or other damage. Downward deflection of the base shall not exceed 0.75 in (19 mm) under these conditions. (Reference ISO 1496-1)

F3.4.8.2 Stacking capability. The fully-loaded containers shall be capable of supporting a superimposed mass equal to five fully-loaded standard ISO 668 1C freight containers (GW 52,900 lbs (23,995 kg) each), taking into account conditions aboard ships at sea which can impose vertical accelerations of up to 1.8g, and the relative eccentricities between superimposed containers of up to 1 in. (2.5 mm) laterally and up to 1.5 in. (3.8 mm) longitudinally. (Reference ISO 1496-1)

F3.4.8.3 Panel strength. In addition to their contribution to the overall strength of the container, the panels used as structural members of the container shall meet the following requirements.

F3.4.8.3.1 Side walls. Each side wall of the container shall be capable of withstanding a uniformly distributed internal load of 5820 lb (2640 kg) applied separately and arranged to allow free deflection of the wall, without suffering structural damage or loss of serviceability. (Reference ASTM E 1976)

F3.4.8.3.2 End walls. Each end wall of the container shall be capable of withstanding a uniformly distributed internal load of 3880 lb (1760 kg) applied separately and arranged to allow free deflection of the wall, without suffering structural damage or loss of serviceability. (Reference ASTM E 1976)

F3.4.8.4 Transverse rigidity. The container end structures (end frames in combination with their end walls) shall be sufficiently rigid to withstand the transverse racking forces resulting from ship movement without sustaining permanent deformation or other damage that renders the container unsuitable for use. The container end structures shall be capable of withstanding tension and compression forces of 33,700 lbs (150 kN) applied against each upper corner fitting with the container restrained by anchor devices acting through the bottom apertures of the lower corner fittings. The forces shall be applied along a vector parallel to both the container base and the plane of the end frame. The end frame shall be restrained in such a manner that the lower corner fitting directly beneath the applied force is restrained from vertical movement and the other corner fitting, diagonally opposite the applied force on that end, is restrained from lateral movement. The sideways deflection of the top of the container end frame with respect to the bottom of the container end frame at the times it is subjected to the full transverse force shall not cause the sum of the changes in the length of the diagonals to exceed 2.36 in (60 mm). (Reference ISO 1496-1)

F3.4.8.5 Longitudinal rigidity. The container side structures (top and bottom side rails in combination with their side wall and corner structures) shall be sufficiently rigid to withstand the longitudinal racking forces resulting from ship movement without sustaining permanent deformation or other damage that renders the container unsuitable for use. The container side structures shall be capable of withstanding tension and compression forces of 16,850 lbs (75 kN) applied against each upper corner fitting with the container restrained by anchor devices acting through the bottom apertures of the lower corner fittings. The forces shall be applied along a vector parallel to both the container base and the plane of the side structure. The side structure shall be restrained in such a manner that the lower corner fitting directly beneath the applied force is restrained from vertical movement and the other corner fitting, diagonally opposite the applied force on that side, is restrained from lateral movement. The sideways deflection of

## DFP-420

the top of the container side with respect to the bottom of the container side at the times it is subjected to the full transverse force shall not cause the sum of the changes in the length of the diagonals to exceed 1.0 in (25 mm). (Reference ISO 1496-1)

F3.4.9 Rail transport. In rail transport mode the fully-loaded container with generator and ECU installed shall withstand without loss of serviceability the shock and vibration imparted by coupling rail cars at impact speeds up to 8 miles per hour (mph), both when mounted on rail cars with ISO corner locks and on standard flatcars.

F3.4.9.1 ISO lock rail car restraint capability. The container, with the generator and ECU installed, and a uniformly distributed payload anchored to the cargo floor such that the gross weight equals 15,000 lbs (6875 kg), and solidly anchored on one end through the bottom apertures of the lower corner blocks, shall withstand a force of 30,000 lbs equally divided and applied horizontally to the container through the bottom apertures of the lower corner fittings on the other end, both towards and away from the anchor points, without suffering structural damage or loss of serviceability. (Reference ISO 1496-1)

F3.4.9.2 Standard flatcars restraint capability. The contractor shall provide a recommended method for restraining the containers to flatcars in accordance with the standard loading methods shown in Section No. 6 of the "Rules Governing the Loading of Department of Defense Materiel on Open Top Cars," that will enable the container to withstand the shock and vibration imparted by coupling rail cars at impact speeds up to 8 mph (13 kph). (Reference MIL-STD-810)

F3.4.10 Motor vehicle transport.

F3.4.10.1 Load transfer area. The container bases shall have end transverse members and intermediate transverse members or other support of sufficient strength to permit vertical transfer of the containers' rated gross load to or from the longitudinal members of a carrying vehicle that lacks ISO corner locks. Such longitudinal members are assumed to lie within the two 10 in. (25 mm) wide zones defined by the broken lines in Figure F-1. (Reference ISO 1496-1)